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Facts About Furs
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A Doctorate Program at Syracuse University for the Preparation of College Teachers in the Sciences
By Richard R. Armacost, Chairman of the Committee in charge of the program, Syracuse, N. Y.

Work With Daphnia

• By **Benjamin Towne, M.A.,** *(Columbia University)*
DEPARTMENT OF BIOLOGY, STUYVESANT HIGH SCHOOL, NEW YORK, NEW YORK

The writer of this article learned how to culture Daphnia successfully by the simple trial and error method which he explains in detail.

He recommends the use of this minute animal for laboratory experimentation since it lends itself well to the study of a number of living organs and life processes without dissection, and it excites much interest in the pupil.

A number of research projects are suggested.

●

Daphnia are minute animals commonly found in fresh-water ponds and lakes. Because the narrow body somewhat resembles that of a flea, they are often called "water fleas." Depending on the species, Daphnia may range in size from about one-twelfth of an inch (visible to the naked eye) to microscopic size. A bivaled transparent horn shell or carapace usually encloses the body of the organism, but not the head. The large two-branched second antennae are the main swimming organs. The swimming is rapid and jerky.

Some authorities refer to Daphnia as Cladocerans, while others describe them as minute Crustaceans, related to crayfish. Daphnia are not to be confused with the Crustacean, Cyclops, for in Daphnia the brood or egg sacs are found within the body of the female, while in Cyclops the egg sacs are externally placed one on each side of the female body.

Storer's *General Zoology* classifies Daphnia as follows:

Subkingdom . . . *Metazoa* (referring to a many-celled animal)
Branch . . . *Entozoa* (animals with a digestive cavity)
Phylum . . . *Arthropoda* (jointed-leg animals)
Class . . . *Crustacea** (with an exoskeleton of lime deposits)
Subclass . . . *Branchiopoda* (animals with many pairs of lobed foliaceous or leaf-like swimming feet)
Order . . . *Cladocera* (small Branchiopoda, with bodies usually enclosed in a bi-valve shell, with large second antennae for swimming, and four to six pairs of "swimming" feet)
Family . . . *Daphnidae*

*Crustaceans include such animals as Barnacles, Crayfish, Crabs, Lobsters, and Daphnia.

DAPHNIA PULEX

Among the more common species are Daphnia longispina, magna, moina, and pulex. *Longispina*, found the year round in fresh water, is about one-twelfth of an inch in length, having an oval body and a tail-spine almost as long as its body. *Magna*, a reddish-colored species, may turn almost white if raised on yeast. According to one authority it attains a maximum length of from 2 mm. in males to 5 mm. in females. *Daphnia moina*, found in barn-yard puddles and pools in late spring and summer, should do well in cultures to which manure is added. *Daphnia pulex*, our most common species, is found in spring and early summer in ponds, lakes, and pools. It ranges in color from yellow-brown to red. It has a somewhat stout and heavy body, usually not transparent, and attains a maximum length of 2.5 mm.

Culturing Daphnia

About two years ago I began experimenting with Daphnia trying to keep alive some we had obtained from a local pet shop. I divided the culture, adding part to a jar containing freshly drawn tap water, a second part to one containing water that had been allowed to stand for several days ("conditioned water"), and a third part to a jar containing artificial pond water or "Solution A," commonly employed for raising protozoans. No food was added to any of the jars. I confidently expected the pond water to contain sufficient food ingredients to last for several weeks.

In the fresh tap water the rising air bubbles brought the Daphnia to the surface where they became entangled and quickly perished. In the

(Continued on Page 78)

What is Science?

• By **Hanor A. Webb, Ph.D.**, *(George Peabody College)*
DEPARTMENT OF SCIENCE EDUCATION, GEORGE PEABODY COLLEGE FOR TEACHERS, NASHVILLE, TENNESSEE

This is a "five star" article.

When you have finished REREADING it you will agree that it is one of the most piquant, spirit stirring articles we have had the good fortune to publish. It will make you think. It will make you proud. It can do much good. We believe it will.

Teachers everywhere would do well to accept Dr. Webb's invitation to make this material the foundation of a speech. Should they do so the author will be delighted to know of its use.

●

Here is a short, crisp speech for you—to make as your very own. You need not mention my name as a source; I, too, take ideas wherever I find them, if it seems I can do some good in passing them on. After all, "There is no new thing under the sun" (Ecclesiastes 1:9).

If you are articulate at all, you are sure to receive invitations to address lay groups of men and women. The word *lay* means "people" in the ancient Greek; let's translate it "just folks." You do not want to spout deep wisdom to a folksy group—yet you do wish to inform them. Particularly you wish to interest them.

An interesting speaker is the deep desire of the person who invites you. His hope may be expressed in the words of the shortest—and frankest—introduction I ever received: "Tonight we have Professor Webb with us. I have heard that he is a good speaker. In a few moments we will all know whether I have been misinformed."

If you naively ask, "What shall I talk about?" he who invites you may give an honest reply of "about twenty minutes." The speech that follows in later paragraphs is but twelve minutes long, hence you are supposed to fill it out effectively with your own illustrations, and philosophy, for about eight minutes more.

The subject, "What Is Science?" is certainly appropriate for you as a science teacher to take. It will arouse a little curiosity. It is not a controversial title, not boastful, not glamorous. Thus it probably fits your personality. It will be both interesting and instructive, if you make it so.

But we must get on with the speech! The introduction is just over!

What, indeed, is science? It is the life work of countless teachers, researchers, technical experts. It is a factor in our civilization. It is a force for good or for evil. But what is it?

Science, first, is a science. The parent word is the Latin *scire*, "to know." Science, then, is knowledge. Broad knowledge is obtained by observation—as of the spring flowers, the summer clouds, the autumn fruits, the winter weather. Accurate knowledge is obtained by measurements—as of the precise amount of iron in an ore, the length of a radio wave. New knowledge is obtained by experiment—as the effect of penicillin on an infection. Hidden knowledge is obtained by reasoning, as the forecasts of tomorrow's weather.

Precise knowledge is readily obtained in certain areas of science—as in physics. Precision, hence prediction, becomes more difficult in other areas, as physiology; quite difficult in some as in psychology; exceedingly difficult in a few, such as sociology. Theology, a science under certain definitions, lends itself to practically no experiments; you can not test the concepts of the existence of a soul, or of a future life, on a laboratory table.

Science is also an art. The Latin *ars* means "to do." Countless scientists are doers. The young lady in the home economics courses learns the science of foods and of textiles from her textbooks, then practices the art of cooking and sewing in the laboratory or at home. Many an expert botanist teaches at school and raises a garden in some convenient plot. Certain chemists are expert photographers; physicists may sit up late at night with amateur radio transmitters.

When art works without science it is "rule of thumb"; when science works without art it is "ivory tower." The best scientists do not try to separate knowing and doing; they blend the two to make one activity.

Science is a craft. The word *craeft* is ancient Anglo-Saxon for "skill, cunning." Countless persons make their livings by scientific skills. The more skill they acquire, the more useful and highly paid are their services. The "cream" of these craftsmen may be the chief researchers in the industrial and university laboratories, but thousands of very efficient workers are the "milk" of our scientific industries and our science classrooms.

Young men and women who show talent in science should be discovered early, certainly by the time they are in high school. These should be guided into the pleasant occupations of science, including science teaching. Part of their pay will be in money, but much of it in the stimulation of the daily experiences with nature—for

> "Nature is man's teacher. She unfolds her treasures to his search, unseals his eye, illumines his mind, and purifies his heart; an influence breathes from all the sights and sounds of her existence."—*Alfred Street* (1811-1881), U. S. author.

Science is a recreation. The Latin *recreatus* means "to make anew" or "to refresh." And how many, many persons have great fun with science! Some play indoors with hobbies of the home laboratory; others turn the back yard into a winter sanctuary for birds and a summer bed for flowers. Boys build model airplanes while girls design puppet stages, each requiring technical knowledge of mechanics and materials. The amateur photographer divides his time between the bright outdoors and the darkroom. The hiker, the camper, the fisherman, the observant tourist, all draw on such knowledge of natural law as they possess to increase the pleasure of their hobbies. Many persons even read scientific books and magazines "for fun," for the output of these publications is large indeed.

Science is a religion. The word *religio* in Latin means "a restraint." The scientist accepts the admonition to "prove all things; hold fast that which is good" (I Thessalonians 5:21). He is willing to accept truth as a strict master of his thoughts, for "Truth is by its very nature intolerant, exclusive, for every truth is the denial of its opposing error."—*Ernst Luthardt* (1823-1902), German theologian.

The scientist will sing this hymn with any congregation:

"Seize upon truth, wherever found,
Amongst your friends, amongst your foes,
On Christian or on heathen grounds;
The flower's divine where'er it grows!"
—*Isaac Watts* (1674-1748), English preacher and hymnist.

He would agree with *Goethe* (1749-1832, German philosopher) that "the first and last thing required of genius is the love of truth"; in this he would modestly include his own talents under the term *genius*.

Yes, men have died for science, even as they have died for religion. Among the martyrs for their faith are such names as Otto Lilienthal of Prussia, who crashed in his glider in 1896. Victims of the search for cause and cure of yellow fever were Dr. Jesse W. Lazear, who perished during the Cuban experiments in 1900, and Dr. Adrian Stokes who succumbed during the African researches in 1928. Captain Robert Scott froze to death in 1912 on his return journey from the South Pole. Scientists have been killed by exposure to X-rays; cyclotrons have slain a few. An unnamed physicist was fatally exposed during experiments with improved bomb-stuff in 1946.

Countless others have "suffered gladly" in behalf of scientific experiment. They accept the discomforts of disease and the possibility of death in studies of immunity. They risk broken bones and ruptured intestines to measure man's endurance of jet plane velocities. Even the noted "poison squads" of the college nutrition laboratories diet on excess chemicals or deficient vitamins with the faith that their pains contribute to scientific knowledge.

When God gave man "dominion . . . over all the earth" (Genesis 1:26) He linked the spirit of scientific inquiry firmly with the spirit of reverence for the Creator. Countless poets have expressed the thought that "Nature is but a name for an effect whose cause is God." —*William Cowper*, 1731-1800, English poet.

Science is a language. The word comes from the Latin *lingua*, "a tongue"—and indeed that "unruly member" must be used with facility by all teachers of science. Since "the knowledge of words is the gate of scholarship" (*John Wilson*, 1802-1868, Scottish printer and author) the earnest student of science must match many terms with their precise meanings. Our popular words—though exciting at times in their pungency—are usually not sharp enough to serve science. In an hour you may see a "cute" hat, a "cute" girl, a "cute" trumpet player, a "cute" donkey; but in mathematics "acute angle" means exactly two lines and no more, coming together within a definite range of directions. "Pitch" may have a few separate meanings in physics (as "pitch of a tone" and "pitch of a screw"), but these are readily diagrammed and explained. But it is a challenge to a blackboard artist to illustrate "pitching a curve," "pitching a tent," or "pitching woo."

Although every area of science has its words that must be learned before scholarly discussion may ensue, the language of science is more than a mere vocabulary. Since science is a way of thinking, scientific language must be a way of talking. Scientists do not rant and rave before their audiences; they do not use the tricks of the rabble-rouser to drive their ideas into the minds of their listeners. The scientist never seeks to arouse passions and prejudices; he addresses himself to understanding and to wholesome ambition. Although he speaks the truth, he expects truth to speak for itself when it reaches the minds of his listeners.

The scientist's manner of speaking, therefore, is in the spirit of his investigations. He speaks accurately, patiently, clearly; he goes step by step. He adapts his explanations to the information and interest levels of his audience, just as his experiments must be adapted to their conditions (as of temperature and pressure). No scientist would attempt to develop photographic films out in bright sunlight; no scientist should attempt to use research language before a high school class. Even a "popular" explanation of Einstein's new Unified Field Theory would be understood by some college students, a few high school students, and no pupils in the grades. The maxim that "What's one man's poison, signior, is another's meat and drink" (*Francis Beaumont*, 1585-1615, and *John Fletcher*, 1576-1625, English dramatists) certainly applies to speeches!

Science is a humanity. The latin *humanus* implies mankind as a group, in contrast to *homo*, the individual man. Through centuries of earnest teaching the philosophers have developed types of courses they call "the humanities," which they hopefully believe will give culture to the human race. But what is culture? In Latin this means "tilling of the soil." This tillage brings harvests, not weeds. So men's minds may be stirred by the tools of thought to bring forth a harvest of high ideals, refined tastes, appreciation of beauty, enjoyment of a peaceful society, reverence for God,

(Continued on Page 76)

Earthworms Rejuvenate the Soil

● **By Lawrence C. Lemmon, B.S. in L.A.,** *(Pennsylvania State College)*
CAPITAL EARTHWORM FARM, ARLINGTON, VIRGINIA

Everybody likes to garden. Then this is a story for everybody, as well as for gardeners and for conservationists in particular.

It tells how an observing and thoughtful landscape architect solved the problem of making rich top soil out of the barren subsoil that once encircled his home, and incidentally how a hobby became a business.

You will enjoy reading how his first small purchase of earthworms soon filled his cellar to overflowing with the boxes in which they were grown. You will learn how and why to use a straw mulch in your garden in summer and how you may do away with chemical fertilizers and insecticides. You will be interested in the writer's ideas about conservation in general.

●

When the first settlers came to these shores they were confronted with Nature's bounty in all its primeval abundance. Timber was wantonly cut and burned to make clearings for field crops. As soon as the soil was broken, erosion set in, and in the space of a generation the once rich soil was played out and had to be abandoned. The country was young, and there was always more land to the west to be had for the taking.

A few far-sighted persons, such as George Washington, observed what was happening with misgiving, but for the most part the ever increasing population gave no thought to the future of this great new country. As a result, one of the most inglorious aspects of our history is the story of how we, as a people, squandered and destroyed the greatest natural heritage that ever blessed a young nation at its birth.

Because of this thoughtlessness, we of the present generation must come face to face with stark reality. Our forests have dwindled to a point where they are inadequate to meet our everyday needs. We now have to import forest products. Our rivers and streams are so loaded with mud and pollution that they no longer support the abundance of fish once found in their waters. They alternate between flood and drought, causing great expense and misery. Our fields have steadily become less productive. We try to bolster the yield of our sick and dying soil by the addition of chemical fertilizers. For a while this offered some hope; then we discovered that to be effective the quantity of these chemicals must be increased annually. The soil becomes more lifeless each succeeding year, and finally has to be abandoned.

What is the answer? Is desolation to be the fate of this great land? Is there no other course for intelligent men?

I believe there is, and I believe that this generation is beginning to find it.

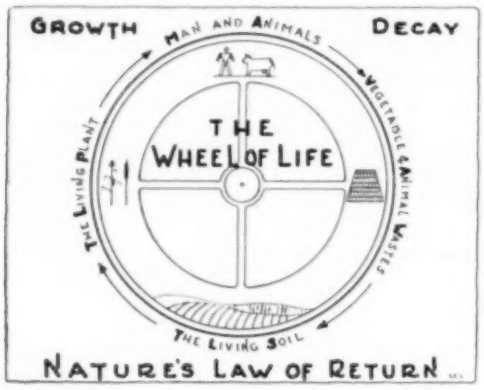
We now turn to Nature and discover that new soil can be made. Nature takes many centuries to lay down one inch of fertile top soil, but man can in the space of a few years produce several inches of rich topsoil from subsoil which would scarcely support the scrubbiest weeds. We like to refer to the process by which this is done as *Nature's law of return.*

Instead of burning, or flushing our wastes into our rivers, we now return them to the soil whence they sprang. Here the earthworms, bacteria, fungi, and many other forms of life, encouraged to return to the soil by the presence of their natural food, waste organic matter, feed upon it and digest it, creating an end-product *humus.* During this digestive process minute quantities of carbonic acid are released in the soil. This acid etches the minerals from the grains of sand and the particles of clay so that once again the soil contains in soluble form all the ingredients needed by the plant roots. A more abundant crop is the result. When all of this crop is returned to the soil, either directly or indirectly, an ever increasing supply of organic matter is available for soil life to feed upon. This means more

BOX CULTURE — The ideal way for the beginner to get started raising earthworms. The author watering a battery of boxes.

plant food each succeeding year; in other words, more topsoil.

Since the success or failure of any landscape planting is to a great extent dependent upon the health and vigor of the soil, I quite early became interested in soil and soil health. It is futile to plant healthy plants in cold, lifeless soil. Soon such plants will sicken and be subject to the inroads of insect pests.



THIS CHART shows the interrelationship of all life both in and upon the soil.

In February, 1944, I purchased a new suburban home in Arlington, Virginia. The house was delightful, all that we were looking for, but the red Virginia subsoil which surrounded it was only what the builder had excavated in making a basement. Here was a challenge and an opportunity to try some of the theories I had had in mind. My wife was as anxious as I to do something about improving this soil. So, even before we were completely established indoors, we were breasting the March winds and freezing our finger tips setting out trees and berry bushes.

Since we began this venture during the war years, we hoped to have the little plot of ground produce the greatest abundance possible. Instead of ornamentals, we went in for fruiting trees and shrubs and all the garden vegetables that could be crowded into the available area. As a result of this activity every square foot of our soil was turned over. Not a single earthworm was found! This fact alone was a pretty good indication that the soil was dead.

Trees, shrubs, and garden vegetables all got off to a rather poor start. However, I believed that were I to mulch everything heavily with straw, soil water would be conserved and possibly soil life might be induced to return. A mulch of straw several inches deep when compacted was the wonder of all our neighbors. Who had ever heard of a row of beans with a summer mulch! But this deep mulching was to pay off. Our soil began to respond to the treatment, and we had some food from the area the first year.

In the fall we collected several tons of leaves and from them made a compost of sorts. A winter cover crop was planted which was to be turned under in the spring along with the partially broken down leaves which had been composted. The soil was beginning to show slight signs of improvement and this encouraged us. A new crop went into the ground and again a heavy mulch was laid down. This second year our garden was entered in the Washington Victory Garden contest. It won second place for Arlington County.

We then came upon a story of how a man in California had made a remarkable improvement in a piece of desert land by introducing the earthworm in abundance. We purchased $40.00 worth of the worms and read everything we could about their habits and culture. In a few months our investment had increased, because of the remarkable fecundity of this worm, to an estimated worth of several hundred dollars. Now we were ready to take a part of this horde from the culture boxes and place them in the garden and under our trees and shrubs. The straw mulch began to disappear more rapidly and had to be replenished several times during the growing season. The abundance and vigor of our growing things began to reflect the improvement which was taking place in the soil.

As we were doing without chemical fertilizers, the next logical step was to discontinue the use of all chemical dusts and sprays. We knew that nature used no such things, and we felt that as the health of the soil was restored the health of our plants would grow apace. We reasoned that a healthy, well nourished plant must have its own protective characteristics. Anyway, we were going to give the matter a trial.

We had begun raising worms in lug boxes in our basement. From time to time we placed part of our increase in the soil about our trees and shrubs and wherever we had anything growing. Before long we had worms in ever increasing numbers indoors and out. As these worms more than double their number every thirty days, we soon had our basement filled with lug boxes in spite of the fact that we had begun to sell worms to other gardeners. At one time we were caring for nearly one hundred boxes filled with worms with the prospect of that number's doubling within the next thirty days. The whole thing was getting just too big to handle. To solve the problem we decided to transfer all our worms to large compost pits out of doors. This move made it much easier to care for several million worms. The demand for the worms has increased each year, and the outdoor pits proved to be the right answer for the practical production of large quantities of worms.

The earthworm is one of Nature's scavengers. His natural food is dead plant and animal refuse, as well as small particles of the mineral soil through which he moves in his burrowing. Matter such as dead leaves, grasses, straw, weeds, table refuse, etc., all types of animal manure, clay and sand are taken into the gizzard of the earthworm and mixed with its digestive juices. The worm is nourished, and the refuse of digestion along with other body wastes is passed off as castings. These castings are humus in its pure state. Upon analysis the castings are shown to contain in soluble form very large percentages of nitrogen, potassium, phosphate and calcium, as well as many of the trace

FIVE JARS OF EARTH—Showing the remarkable change made in a soil in a four year period.

1. Red Virginia sand of 1944 devoid of all soil life.

2. The same soil, but by 1945 heavy summer mulching had made it darker and more crumbly.

3. The earthworm had been introduced and the humus content had risen in 1946.

4. By 1947, earthworms had been at work for more than a year and the soil was warmer, darker and more friable.

5. 1948. Same soil as that of jar 1 after four years of following *Nature's Law of Return.*

elements. Thus it would appear that chemical fertilizers are unnecessary where there is an abundance of waste matter and plenty of worms to change it to humus.

The water-retaining quality of castings is remarkable. Laboratory tests have shown that they will retain two and one-half times their own weight of water. This fact alone, as was indicated by the experiments of Dr. Hopp of the United States Department of Agriculture, Soil Conservation Service, means that where there is a large earthworm population, soil erosion is slowed up considerably. Rain water, instead of running off and causing trouble, will be absorbed by the soil and given up much more slowly, thus helping to obviate the double curse of flood and drought.

Upon analysis, it was found that earthworm castings contain a count of over 12 billion aerobic bacteria per gram. For comparison, fertile soil has up to five hundred million. When all these factors are considered, one can readily see how a cold, lifeless, mineral soil which cakes over after every rain can be completely transformed by introducing earthworms under a heavy mulch of leaves and the waste which the average householder usually destroys by burning.

When we took over in the spring of 1944, we hit upon the idea of keeping a sample of the soil from our garden each year to have a visible record of what progress, if any, we might be able to make in transforming subsoil into rich topsoil. Our success in this venture is now a matter of record. It is indicated by the accompanying illustrations as well as by the many complimentary things that have been written about us by local and national newspapers and magazines. As a result of this venture we now carry on correspondence with folks all over the world who are anxious to improve their own soil. Our own garden has become a show place where visitors are always welcome.

We still have some insect pests, but they do very little damage in spite of the fact that for five years we have not used a bit of insecticide. Our plants are now so vigorous and healthy that they are well able to take care of themselves. Perhaps these so-called pests are nature's monitors whose duty it is to keep the race of plants strong and vigorous by eliminating the weaklings. The cucumber beetle is probably as old as the cucumber vine. If the vine under Nature's care had succumbed as readily as it sometimes does in our modern gardens, it would very early have been eliminated from the race. It was not eliminated; so there must have been a reason. We believe that the reason lay in the soil in which the plant grew. The soil was in good health, therefore the plant which grew in it was a healthy plant.

When Peter Henderson, the founder of the great seed house which bears his name, was growing garden vegetables on Long Island for the New York market more than a hundred years ago, he found time to write a gardener's manual. This manual, which discusses the problems of the professional gardener of that time, gives very little notice to insect pests. The obvious conclusion is that garden insects were not the pests they are today. The soil was nearer to its virgin state and could produce strong healthy plants.

We believe that if all matter were returned to the soil, either by proper composting or by mulching,

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TOMATO PLANT. July, 1948. The height of the plant and the size of its fruit shows what a healthy soil can produce. Note the vigor of the bean vine and the heavy mulch on the ground.

Sulfur and Life

• By W. W. Duecker, Ph.D., *(Iowa State College)*
MANAGER, RESEARCH DEPARTMENT, TEXAS GULF SULPHUR COMPANY, INCORPORATED, NEW YORK, NEW YORK

For many years the sulfur content of the soil and its relationship to plant and animal nutrition were not fully understood. When improved analytical procedures were introduced, it became apparent that sometimes we were unknowingly depleting the supply of sulfur in the soil to an extent that caused a serious reduction in soil fertility. Studies involving the use of radioactive sulfur are expected to uncover new knowledge concerning the function of sulfur in the soil and in the cycle of life.

This paper, presented at the 1949 Atlantic City meeting of the American Chemical Society, was kindly released by the Society for publication in THE SCIENCE COUNSELOR.

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The feeding of animals and human beings is a great science as well as an art. Years ago scientists thought it was simply a problem of providing certain proteins, fats, carbohydrates and minerals. Today we know there is more to it than this. Today we know that nutrition must be considered in connection with the great cycle of life made up of the soil, the atmosphere, the plant and the animal. In this cycle, certain simple basic elements are assembled by green plants in constructive processes of food manufacture, disassembled by non-green plants and animals in the destructive processes of food utilization, and then returned to the soil. A brief review is here presented of the part that sulfur plays in this cycle of life.

Sulfur and Soils

Basically, nutrition begins with the soil. It is from the soil that plants, animals and men obtain the dozen or more mineral elements including sulfur that are necessary for their existence. The earth's crust from which soil is formed, according to Clark, contains 0.06% of sulfur in the form of elemental sulfur, sulfides or sulfates. In good mineral soils there seldom is less than 0.03 to 0.04% of sulfur, most of which appears to be contained in organic matter. The major portion of the remainder is probably present as sulfate ion. The presence of these sulfur compounds and sulfur in the soil is said to improve its structure and physical condition. They help to modify soil reaction. They increase its water holding capacity. Sulfates, through ion exchange, bring about the liberation of other basic nutrients such as calcium, magnesium, potassium and phosphorous and make them available to plants. Sulfur compounds neutralize alkaline soils and make them fit for cultivation. Sulfur compounds also stimulate the growth of essential soil micro-organisms.

Sulfur and Plants

The fact that sulfur is indispensable in plant nutrition has been recognized for more than a century. If there is insufficient sulfur in the soil, plant growth is slow and stunted. Sulfur seems to encourage vigorous plant growth and increase root development. It promotes nodule formation in legumes. It stimulates seed production. And lastly, when the sulfur supply is low the leaves of plants are spotted or light green in color, indicating that it may be essential in the formation of chlorophyll.

Sulfur's Role in Agriculture Neglected

Although sulfur has long been recognized as being indispensable in plant nutrition, for many years little attention was accorded the importance of the sulfur content of soils, and no attempt was made to correlate this with plant growth. This was due in part to the lack of proper analytical techniques for determining the sulfur content of plants. It was supposed that all soils contained more than enough sulfur to supply the conceivable needs of the plant. Attention had been called in the middle of the Eighteenth Century to the fact that applications of gypsum gave increased yields of clover. As a result, the use of gypsum as a fertilizer became quite general in Europe. It was introduced to this country by Benjamin Franklin. But when researchers in England, in about 1840, became convinced that the benefits derived from gypsum were due to the calcium ion and to increases in the availability of potassium in the soil due to base exchange, interest in sulfur declined.

At this time also, the manufacture and use of superphosphate fertilizers was initiated. These contained about 10 to 12 per cent of sulfur in the form of calcium sulfate. These were further modified by the addition of potassium sulfate and ammonium sulfate which contain about 23 per cent of sulfur. And, since the widespread use of the new fertilizers brought sulfur to soils which had not received it before, and furnished sufficient sulfur to prevent the deficiency of this element, the study of the relation of sulfur to soil fertility was neglected.

For the next fifty years little was added to the knowledge of the place of sulfur in plant nutrition and its role in the soil. Advances in knowledge had to wait for the development of new tools for research. These became available shortly after the turn of the century when better analytical methods for determining the sulfur content of plants were developed. When they were applied to the sulfur problem it was discovered that contrary to general opinion all soils do not contain sufficient sulfur to supply the needs of plants. It then became evident that the question of the content of

sulfur in soils as related to plant nutrition had to be reappraised. Since that time increasing attention has been accorded sulfur in the soil and its relation to soil fertility and plant nutrition. Now it is generally recognized that soils in general may be more deficient in sulfur than in phosphorous.

Sulfur in Plant Nutrition

The sulfur content of soil generally is low in comparison with other elements. Plants, however, possess a very evident faculty of assimilating it in much greater quantities than its abundance in the soil might lead one to suppose. Thus the ratio of sulfur in the soil to sulfur in food plants is approximately 1 to 30. It is present in all plants in considerable quantity. It is usually assimilated in the form of sulfate, and the sulfur requirements of the various plants vary greatly as judged by their mineral composition. Grain and grasses contain the least. High protein grain, such as wheat, generally contains over 0.3 per cent. Alfalfa and legumes are intermediate. In cabbages, onions and broccoli it reaches a concentration of several per cent. It has been estimated that it takes approximately 78 pounds of sulfur to produce a 100-bushel crop of corn.

Although sulfur is absorbed as the sulfate ion, it generally is found in the plant in the form of complex organic sulfur compounds. These may be of various kinds. In the mustard family sulfur is found in the form of sulfur glucosides. In onions and garlic it is present in the form of mercaptans. Based on present knowledge, the most important, however, from the viewpoint of nutrition of humans and animals, are the sulfur-containing proteins synthesized by plants and the substances from which vitamins are formed.

Sulfur in Nutrition of Humans and Animals

In the nutrition of humans and animals, sulfur generally is not considered in connection with the mineral elements. This is because sulfur plays its important role in the body not in the form of inorganic substances, but in the form of complex organic compounds. Moreover, practically all of the sulfur obtained by humans and animals is obtained in food, chiefly in the form of protein, and not as inorganic compounds. The fact that sulfur somehow or other was related to human nutrition and well-being has been long recognized. Grandmothers of a generation or so ago may not have known why, but they did recognize the fact that a dose of sulfur and molasses in the spring had a beneficial effect on children.

Sulfur is very necessary for the maintenance of human health and well-being. If it were not for the complex organic sulfur compounds which animals obtain from plants, all higher animals existing today would eventually perish. These sulfur compounds are of various kinds. Sulfur-containing protein is particularly important. Protein is the essential constituent of all living cells. Nothing else can take its place in building new tissues in the body or replacing losses. Protein, in turn, as far as human nutrition is concerned, is synthesized from ten basic amino acids. One of these ten is a sulfur-containing amino acid called methionine. If methionine is withdrawn from the diet, growth ceases or is generally retarded. There are other sulfur-containing amino acids and one of these, cystine, constitutes a large part of the skin, hair and nails; but none is as important as methionine.

Sulfur-containing protein material or certain amino acid residues are also essential parts of many of the enzymes and hormones which regulate complex biological reactions. Another sulfur-containing compound is vitamin B_1, or thiamin. This is essential for the well-being of every living cell and for the normal growth of all species of animals, of yeasts and molds, and of higher plants. Many of these compounds are obtained only from plants, and since practically all of the sulfur plants need is obtained from the soil, the question of soil fertility in terms of sulfur becomes exceedingly important. In connection with the well-being of humans and animals, mention should also be made of a new group of sulfur compounds, the sulfa drugs and penicillin, which have become increasingly important in the control of disease.

Sulfur Balance in Soil

Normally in the cycle of life it is expected that all plant and animal residues will be returned to the land. The same basic elements therefore would be used over and over again. But, unfortunately, the sulfur cycle is sometimes thrown out of balance with the result that often more sulfur is removed from the soil than is added. This question of an adequate supply of sulfur in the soil has recently been accorded increasing attention. Lipman attempted to strike a balance and to determine whether in the normal course of events the sulfur supplies in the soil were augmented or depleted.

Roughly speaking, the sulfur removed by cultivated crops and grasses is compensated for by applications of animal manure and commercial fertilizers. But due to the ever-increasing use of tractor power, the supplies of barnyard manure returned to cultivated land have diminished considerably. Some sulfur is added from the atmosphere by rain and snow. Some is added to soils in irrigated regions by the irrigation water. But taking all of these additions into consideration, and balancing them against sulfur losses due to leaching, drainage, erosion and removal by crops, Lipman came to the conclusion that the sulfur supplies in the soil are gradually being depleted. According to his data, the land in cultivation in the United States including the areas given to crop production, to pastures and to woodland grazing, annually loses about one million tons of sulfur. He then asks "whether the more or less far-reaching changes coming into our fertilizer industry, coupled with the crop intensification program which must become a part of our new agriculture, may not justify a careful study of our plant-food resources."

Summary

It was eighteen years ago when Lipman suggested a reappraisal of the role of sulfur in agriculture. Since that time considerable new information has been ob-

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On the Path of an Eclipse in China

● By **Francis J. Heyden, S.J., Ph.D.,** *(Harvard University)*
DIRECTOR, GEORGETOWN COLLEGE OBSERVATORY, WASHINGTON, D. C.

It is unlikely that you will ever be called upon to lead a scientific expedition to the Far East, but in this charming human interest story you may enjoy the experience vicariously.

Many difficulties were surmounted by the writer as he traveled to China to photograph the eclipse of the sun of May 9, 1948. Strayed shipments had to be recovered, surveying done, a camp site selected, the recorder repaired, machine adjustments made, the weather watched.

The final outcome will interest you.

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In November of 1947 Dr. Lyman Briggs, scientific adviser to the National Geographic Society, asked, "Will you take charge of the eclipse camp in China?" There were to be seven different camps spread out along the path of the eclipse of the sun of May 9, 1948, between Burma and the Aleutians. Outside of Bangkok which was right on the path of the eclipse, all of the other stations were rather far from the beaten paths known to commerce and tourists. Whether I went to the jungles of Burma or to the icy tundra of Adak, I was bound for a lot of rough and tumble traveling. I agreed to go to China.

Why set up seven different camps? There were two very good reasons. First, the weathermen were reluctant to give us a better than fifty-fifty chance for good weather at any of the seven places. The southwest monsoon was due over Burma and Bangkok. In China, Korea and Japan the usual unsettled weather of springtime was going to be predominant. In the Aleutians the weather was always bad. But it would be an unusual calamity if all seven stations were bogged down under clouds on the same day. Secondly, there was a scientific purpose. If two or more of the stations obtained successful observations, the results would contribute valuable information toward a better knowledge of the shape and dimensions of the earth. Not this one, but several such eclipses, during perhaps a few generations, would have to be observed in this way to obtain all of the necessary scientific data. This was the time to start.

The Chinese Land Survey provided us with a set of large scale topographic charts of the countryside near Hangchow, and the predicted path of the eclipse was drawn on these. Then began the task of reconnoitering. Wherever we went, roads were essential for hauling a ton and a half of scientific equipment besides our tents, cots and rations. A fine road led out to a town named Wukang, but the symbols on the map indicated swamps and rice paddies. Twelve miles southwest of Wukang the eclipse path stretched over a cluster of mountains. In the midst of these the map showed a group of black dots, which meant a village too tiny to merit a name on the map. A road passed right by it. We decided that we would go there first, and if it looked in reality as advantageous as it did on the map, we would set up our camp and observing station there.

My orders for the trip were prepared in the Pentagon. Big Army planes were to carry my radio operator, my cameraman, Mr. Joe Gray, and myself all the way to Hangchow. Our equipment would follow us as quickly as possible by air freight.

We landed in Manila on the way to check on the availability of supplies and a surveying team. In case these could not be had in Shanghai or in Japan, Manila was to provide them. I was glad for the chance to see Manila again. I spent eight days looking over the sad ruins of the once beautiful city, and one morning I climbed through the broken rubble of the astronomical ob-

EAST WORKS WITH WEST FOR ECLIPSE—The No. 1 and No. 2 men of the National Geographic Society expedition to study the May 8-9, 1948, eclipse from Wu-k'ang, China, confer beside a geodetic bench mark used to locate their observation site. Rev. F. J. Heyden, S. J., Director of Georgetown College Observatory, Washington, D. C., and the expedition's chief astronomer, is on the left. With him is Dr. Yu-Che Chang, Director of the Astronomical Research Institute, Kunming, China, who is acting as assistant astronomer. Some of the expedition's equipment appears in the foreground.
©National Geographic Society Photo.

servatory where I had worked as chief astronomer for three years before the war. The twisted and fire-seared skeleton of the nineteen inch telescope still stood inside the shattered steel dome. The devastation of the city was thorough.

On Easter Sunday I learned that our supplies and surveyors were waiting for us in Shanghai. The midnight plane that flew us from Manila to Okinawa was crowded. Comfort was at a minimum and sleep was impossible. In the early morning hours the pilot sat on the floor in front of me to talk for a few minutes. He pointed to the boxes of freight that were lashed to the floor of the plane and told me about a fire that had occurred just two days before in a similar pile of boxes on another plane. A lot of photographic film had ignited somehow or other. Most of the burning boxes were jettisoned into the China Sea. The poor pilot! He never realized how Joe Gray and I had been worrying over our own scientific equipment which contained two thousand feet of special film. We said nothing to him, but spent the rest of the night talking about the catastrophe which we were sure was ours.

At dawn the big plane put us off at Naha airfield on Okinawa. I lost no time in reaching the air freight office and inquiring about our shipment. It was a relief to hear that everything had passed through Naha safely on the preceding day. But this reassurance was not for long. At daybreak on the following day we boarded a Navy plane for Shanghai. The pilot was a graduate of Rockhurst College in Kansas City, and hearing beforehand that a Jesuit was coming along with his flight as a passenger, had ordered a pair of deluxe plush seats mounted in his plane. An Indian potentate could not have been more honored, but Joe Gray and I were a trifle embarrassed with the many eyes of the other passengers focussed on us. I went forward on the double when the commander invited me in to watch him fly the plane.

"E-DAY" PREPARATIONS—Members of the National Geographic Society Expedition to study the May 8-9, 1948, solar eclipse from Wu-k'ang, China, check over the long-range sky camera that would be used to "shoot" all phases of the sun's blackout on sound movie film at the rate of 24 photographs per second. Left to right: Dr. Yu-Che Chang, Director of China's Astronomical Research Institute; Rev. F. J. Heyden, S. J., Director of Georgetown College Observatory, Washington, D. C., and chief astronomer for the expedition, and Lt. Nelson J. Fay, U. S. Army Engineers.

© National Geographic Society Photo.

We were almost ahead of our orders when we reached Shanghai. Our surveyors had not yet arrived from Tokyo. The American adjutant had just taken over his job and confessed sheepishly that he knew nothing about us and would have to look up the records. We set out to find a place to stay until our personnel and equipment arrived.

Father Gherzi, the Jesuit meteorologist at Zi-ka-wei observatory on the outskirts of Shanghai, provided us with rooms for the next two days. Zi-ka-wei observatory is famous for its weather forecasts which the Jesuits have sent out from there for the past seventy years. Prior to the war it had a large staff of Chinese workers under the direction of Father Gherzi. The large shipping companies of all countries maintained the observatory with generous donations. After the war, the staff, except one volunteer, had left for better paying jobs, all donations had stopped, and the Chinese Nationalist government was paying Father Gherzi about fifteen American dollars a month to make forecasts for Shanghai and eastern China. The observatory was a dying institution. Since the Communist occupation last summer, Father Gherzi has left China and is now opening a small observatory in the Portuguese colony of Macau, just north of Hong Kong.

Lt. Nelson Fay, who had been assigned by the Army to manage my camp, called me on the phone. He was amazed to find us taking refuge at Zi-ka-wei because the Army had reserved rooms for us at the New Asia Hotel which was operated for American Army per-

sonnel. We moved there at once, and then went to the big Army warehouse, or godown, to check our equipment.

"Yes sir," said the Major in charge of the godown, "everything is here safe—all twenty-nine boxes." I had the feeling of a man in a guillotine just as the heavy blade begins to fall. We had started out with thirty-four boxes of equipment. There was nothing to do but to go on a very intensive box hunt. Checking our inventory sheets, we discovered that the missing five boxes contained our special motion picture film. The horrors of the pilot's story between Manila and Okinawa returned with an awful shock.

Rather dazed I set out for the office of the Air Transport Command. Would they please check back over the route taken by our freight as quickly as possible? I prepared a cable for the National Geographic coordinator in Tokyo asking for replacement of the contents of the five boxes. But how could those items—special cables for our motion picture camera, specially prepared motion picture film and radio parts built at the Bureau of Standards only for our radio—be replaced and shipped from Washington within three weeks? I went to the Navy and described my losses. They were sympathetic but had nothing to loan me. I went to the Signal Corps and to the Army Engineers without any success. I returned to the godown and begged the officer in charge to check over his own supplies. I was sure that no one in China could replace those five boxes.

The boxes were found on the following day in the warehouse at Kiangwan airport outside of Shanghai. I relaxed for the first time in days. After all, yesterday was April the first. What an unintentional April Fool's joke!

Within a week Lt. Fay had collected a huge truck full of tents, sleeping bags, cooking equipment, and provisions to last for a month. Once at our camp we wanted to be as self-sufficient as possible. While I took charge of bringing the ton and a half of scientific equipment down to Hangchow by plane, Lt. Fay drove the truck, with a two hundred and fifty gallon water-cart trailing behind over the dusty one hundred and thirty-five miles to Hangchow. In two days we were established at the little village we had found on the map. Its Chinese name was "The Meeting of the Four Ways" and we named it "Four Corners."

Now began the search for the best site for the eclipse camera and the other equipment. I had to consult our surveyors whose job it was to fix the exact location of our site. All of the control markers which had been placed by Chinese surveyors many years before were on mountain tops in the area, and since we had to have a first class position with respect to these markers, we chose the top of the mountain overlooking our village. The trail to the top was about two miles long. In many places the dry bed of a mountain rivulet was the only evidence of its existence. Frequent forks in the trail led off to other valleys and mountains. One had to learn the trail the first time up and remember it well. I took the wrong turn one night and wandered through the mountains for several miles with my arms full of books and food rations. We never traveled alone at night after that. I named our mountain-top observatory, "Wun Long Climb."

The eclipse camp was managed by Lt. Fay. He took charge of the cooks who stayed in the base camp near the village, and hired the village farmers at generous salaries to do odd jobs for us. The observatory on the mountain top was in the hands of Dr. Y. C. Chang, Director of Purple Mountain Observatory near Nanking, and myself. The surveying teams began at once to tie in our site with the control points of the Chinese Land Survey. Col. Chow with two other Chinese army officers took charge of bringing the triangulation in from the mountains to the west, and Lt. Carrier of the United States Army Engineers with one assistant worked from the control points to the east. This work was most difficult and trying. The surveying parties climbed mountain after mountain and spent hours searching for markers which had not been inspected for years. A few had disappeared from the places where they had been set some thirty years or more ago.

These mountain tops were not as wild and deserted as they seemed. Every bamboo tree on them bore its owner's peculiar symbol. Our surveyors paid thousands of Chinese dollars for every tree that had to be cut down. During the war the guerrillas had used these same mountains for hide-outs from the Japanese, and vestiges of their little forts still remained. Rarely did the surveyors struggle to the top of one of the mountains without meeting some Chinese farmer or his children searching for tender bamboo shoots—a favorite food in China. With so much traffic around them there was no need to wonder why a few of the markers had disappeared.

While the surveying teams worked, Dr. Chang and I selected a spot on the mountain top which, according to our detailed map, should be right on the central line of the eclipse. We laid concrete foundations for our camera and coelostat. We had only three weeks in which to get our tests and adjustments made. Within an hour after we had raised our radio antenna and charged up our batteries, we heard WWV, the Bureau of Standards time-signal station in Washington. The signals were very weak and it was evident that they would not actuate the automatic recorder on our radio set. Something had to be done quickly about that. But worse apprehensions were in store for us. We discovered that something had happened to our recorder. It would not work on any signals however strong.

Time was precious now. I sent the recorder with the radio operator to Shanghai. He was to try every expert he could find there to get it repaired. Father Gherzi at Zi-ka-wei is an expert at electronics. He repaired it in two days. A soldered connection had broken loose.

In the meantime Lt. Fay and I went on a listening marathon with the receiver. I had done radio longitude work in Manila many years ago and remembered the time signals I used to listen for from different countries.

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Radioactive Isotopes and Medical Treatment

● **Radio Script** *based on information furnished by the Addison H. Gibson Laboratory,* CAMPBELL MOSES, M.D., *Director.* Participating *in the radio presentation:* W. L. COOK, JR., M.D., *Assistant Professor of Medicine,* WILLIAM M. COOPER, M.D., *Department of Medicine, and* FREDERICK R. FRANKE, M.D., *Addison H. Gibson Laboratory, all of the School of Medicine, University of Pittsburgh, Pittsburgh, Pennsylvania.*

Publishing a radio script is a new venture for this journal.

We believe, however, that this unusual style of reporting adds warmth to the presentation of recent authoritative and important information about the use of radioactive elements in medicine.

The script as shown here was broadcast over Pittsburgh's Station WCAE early this year by the three physicians mentioned.

Perhaps you can use it in one of your science classes.

●

ANNOUNCER: Radioactive isotopes are receiving widespread public discussion these days, Dr. Franke. Just what do you mean by a radioactive isotope?

FRANKE: The term, radioactive, means that a particular chemical element spontaneously decays to another element and in this process gives off a ray known as an alpha, beta, or gamma ray. These rays are the factors that are responsible for the radiation effects when these isotopes are used in medical research and treatment.

The gamma ray given off by several radioactive substances, particularly radioactive iodine, is quite similar to one that you are familiar with, X-ray.

ANNOUNCER: What do these rays do? How are they used in the treatment of disease?

FRANKE: Let's take a specific example. Gamma rays are given off from radioactive iodine. Since the thyroid gland has the function normally of concentrating iodine, when radioactive iodine is given, the thyroid gland concentrates this material. The gamma ray emitted by radioactive iodine is then given off within the substance of the thyroid gland itself. Thus, administration of radioiodine actually provides the thyroid with an internal X-ray machine. This means that the radioactivity is directed immediately to the thyroid and not to all the other tissues in surrounding areas.

ANNOUNCER: Dr. Cook, what isotopes are useful besides radioactive iodine?

COOK: A few years ago we had great hope that many of these radioactive substances would be extremely valuable in the treatment of various types of diseases. Indeed, much of the initial enthusiasm for this type of therapy was based upon hope rather than upon careful scientific evaluation. We now know that in only a few diseases do these isotopes provide a better means of treatment than do conventional measures. Specifically, radioactive iodine used in the treatment of certain types of thyroid disorders, and radioactive phosphorus employed in the treatment of polycythemia and certain types of leukemia, have been the only widely used isotopes that have proved to be consistently effective.

ANNOUNCER: Dr. Cooper, surely the extensive program of the Atomic Energy Commission has a broader scope than simply the treatment of these few disorders. Don't the radioactive isotopes have some other use in medicine?

COOPER: Yes, indeed. The major use of isotopes today in medical research is not in the treatment of patients, although this is important, but in providing a new technique for studying various disease processes. This technique, the radioactive tracer technique, enables the investigator actually to trace a molecule through the entire body. This means we are able to learn more about the chemical changes that take place in the body with disease. Investigators hope that by this technique we shall be able to solve the riddle of the cause of cancer. If the cause is known with any accuracy, it may be possible to devise more rational treatment.

ANNOUNCER: Dr. Cook, you said that some of these radioactive isotopes are useful in the treatment of polycythemia and certain types of leukemia. I'm afraid I don't understand what those words mean. Are they common disorders?

COOK: Leukemia is a very common disorder. Although polycythemia is not extremely common, every doctor usually has one or two cases under his guidance. The word leukemia is derived from the Greek words *leukos,* meaning white, and *haima,* meaning blood—white blood. A very well-known 19th century pathologist named Virchow, coined the word leukemia because patients suffering with this disease have white blood. This occurs because the white blood cells multiply tremendously fast so that instead of a normal white count of 5- to 10 thousand cells the individual may have 50- to 100,000 or even 200,000. This over-growth of white cells can be seen as a layer of white on top of normal red blood. It is often looked upon as a form of cancer of the white cells, although in some cases the disease may attack the patient so rapidly that it resembles an acute infectious disease.

COOPER: Polycythemia, on the other hand, refers to excessive multiplication of the red blood cells. Normally, we have somewhere between 4- and 5 million red blood cells per cubic millimeter of blood. In the presence of polycythemia the red blood count may

rise to 7- or 8- or even 9 million cells. This makes the blood thick, and it may interfere with normal circulation, particularly in vital areas such as the brain and heart.

ANNOUNCER: Dr. Cooper, what about the use of radioisotopes in treating patients with these disorders: Are they effective?

COOPER: In polycythemia, the use of radioactive phosphorus is the treatment of choice. Throughout the country there has accumulated a very considerable number of patients who have been treated with radio-phosphorus. With rare exceptions the results have been uniformly good. Previously it had been necessary to use certain chemicals to destroy the red blood cells or to treat with X-ray all the bones of the body that make red blood cells, in an attempt to slow down this red cell production. The radioactive phosphorus fortunately is deposited in the marrow of the bones that make red cells and thereby provides them with radiation which slows down the manufacture of red cells without damaging other parts of the body.

FRANKE: So far as the treatment of leukemia is concerned the results are not nearly as good as is the situation with polycythemia. Moreover, in certain specific types of leukemia the results are encouraging. However, it is most discouraging to recognize that in the very violent types of leukemia which result in the death of a patient in a few days to weeks, neither radioactive phosphorus nor any of the other radioactive substances influences the course of the disease.

ANNOUNCER: Dr. Cook, is it much of a trick to administer these substances? Does the patient actually go in the cyclotron to be treated?

COOK: Not at all. As a matter of fact, both radioactive phosphorus and radioactive iodine may be taken quite effectively by mouth. They're supplied as a tasteless, watery solution that may be readily swallowed. It is necessary for the doctor administering the substance to take precautions to prevent him from being exposed to too much radiation. This is particularly true with radioactive iodine.

ANNOUNCER: What is the dose of these substances? Is it so many teaspoonfuls, or just how is it measured?

FRANKE: An estimation of the dose of radioactive isotopes is a fairly complex affair. It is not possible now and indeed probably never will be possible for the pharmacist to dispense these over the counter as he does aspirin, sedatives, and cough syrup. To determine exactly the amount of radioactive material in a given solution it is necessary to assay this solution, using a Geiger counter apparatus. When this is carefully done it is possible to determine the concentration of a radioactive isotope with a great deal of accuracy. It is, of course, important that great care be taken to avoid an overdose of these drugs because after they are swallowed there is no way to get rid of the radiation effects and irreparable damage may be done.

ANNOUNCER: I've heard that after X-ray treatment people often become quite ill from the effect of the irradiation, and it is widely known that many valuable drugs cause side effects such as nausea and vomiting. Do the radioactive isotopes do this?

COOPER: No. That is one of the advantages of this method of treatment. It is usually possible, when patients are treated with these isotopes, to tell them that they will not become sick from the radiation effects. In patients who have been previously treated with X-ray and became nauseated, this is, of course, a real help.

ANNOUNCER: A standard method of treating an over-active thyroid in the past has been surgery, hasn't it Dr. Cook? Does radioactive iodine mean that it is no longer necessary for patients to have thyroid surgery?

COOK: No. That's not at all the case. These drugs, and especially radioactive iodine, are still in the investigative stage. For example, we know nothing about the results of this type of treatment five years after it has been given. Thyroid surgery has been carried out for many years and we know that 5, 10, and even 20 years later the great majority of patients operated for an active thyroid will remain well. We do know from animal experimental work that radioactive iodine and phosphorus cause no serious later effects; that is, we know they do not cause cancer or any other serious disorder, but we don't know whether they will effectively control symptoms for a long period of time.

FRANKE: May I say that radioactive iodine is certainly not the treatment of choice today for most patients with an overactive thyroid gland? Aside from the long-term results that Dr. Cook mentioned, there is another important consideration, and that is that it takes from many weeks to a few months for a single dose of radioactive iodine to exert its maximal effects. This means the patient may remain ill for a long period before the beneficial effects are noted. In a disease such as hyperthyroidism, where the patient often cannot work because of nervousness, weakness, and loss of weight, it is, of course, important that he be restored to full health as rapidly as possible with safety. Therefore, in most instances it is to the patient's advantage to be treated with more conventional types of treatment rather than with radioisotopes.

ANNOUNCER: We've talked exclusively about radioactive iodine and radioactive phosphorus. Are there other isotopes that are important in the treatment of patients?

COOPER: There are several that have been tried, and one or two have turned out to be quite important. Radioactive gold has been extensively tried in the treatment of cancer, but in almost all instances the

(Continued on Page 75)

The Effect of Radiation on the Properties of Liquids

● By **George Antonoff, D.Sc.,** *(Manchester College)*
DEPARTMENT OF CHEMISTRY, FORDHAM UNIVERSITY, NEW YORK, NEW YORK

The theory of aggregates, outlined by Dr. Antonoff in THE SCIENCE COUNSELOR *for March, 1948, receives support in this scientist's observations of the fluctuations in the physical properties of systems composed of two superposed liquid layers before the systems attain equilibrium.*

The subject matter of this paper has been discussed personally and by correspondence with Dr. Albert Einstein, who like many other important scientists is interested in Dr. Antonoff's findings.

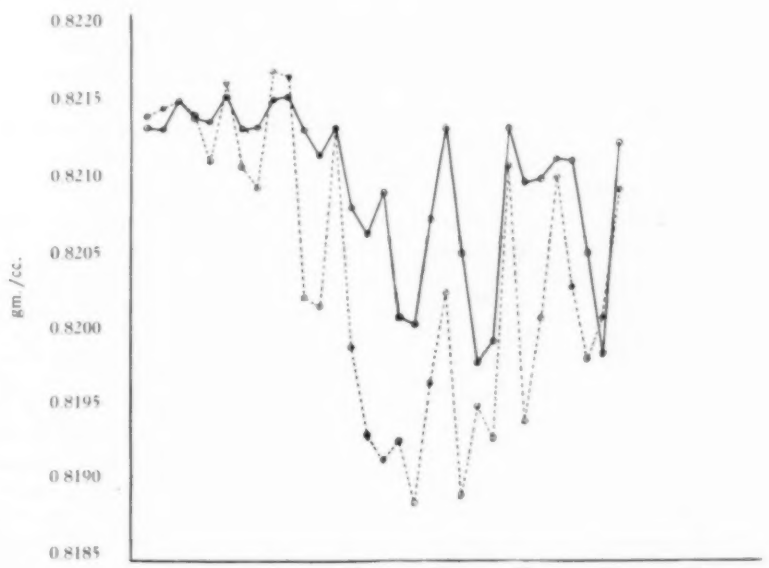
●

It has been observed by the author that in systems consisting of two superposed liquid layers, such as water-benzene, the physical properties fluctuate during a certain period of time until the system attains equilibrium. The time necessary to reach the state of equilibrium varies according to the nature of the system. In the system water-isoamyl alcohol, it was about two months[1]. After this period the system is in equilibrium and the physical properties become stabilized; speaking concretely, it means that in density measurements we no longer observe any fluctuations in the third decimal place. Whether or not there are variations in the fourth or subsequent place does not concern us for the moment, since there we approach the limit of experimental error.

When thermal equilibrium is established, certain aggregates are formed[2]. They are not always stable, and regroupment takes place until stable configurations are reached. It appears probable that in these aggregates the particles are loosely held together and they are likely to be easily disturbed by external agencies. Therefore it was thought that radioactive radiations might produce an effect on the system.

The system investigated was that of water and isoamyl alcohol. Daily determinations of the densities of each of the two layers were made over a period of many months. Two such liquid—liquid systems were observed: in one was placed 300 mg. of radium sealed in a glass tube, thus exposing the liquid directly to strong beta and gamma radiation. This sample will be called "radiated." In the other case the radium preparation was shielded by about two inches of lead and placed about six feet from the liquid. It will be referred to as "non-radiated." Densities were determined by direct weighing of samples of liquid in 25 ml. pycnometers. The isoamyl alcohol was C.P. Distilled water was used without further special purification. At all times both systems were immersed in a thermostat regulated to 30.000 ± 0.005° C.

A portion of the experimental results so obtained is reproduced in figure 1. Some of these results have been referred to in a previous publication[3]. The observed fluctuations were not diminished by the shielding provided for the non-radiated samples, being occasionally even larger in amplitude than those of the radiated sample. This is probably due to the effect of secondary radiation. The fluctuations are apparently quite erratic, for they increase for some days, then decrease, and after a number of days begin to increase again.



Density (gm./cc.) of water-saturated isoamyl alcohol vs. time (days).
———— radiated. - - - - - - non-radiated.

FIG. 1.

At the same time, observations were made with other liquids similarly subjected to radiation. Solutions of aluminum sulphate in water showed changes in weight amounting to about 5 mg. relative to the weight of a filled 25 ml. pycnometer. Assuming the accuracy of an analytical balance to be about 0.2

mg., the above effect was certainly well above the limits of experimental error. Experiments with systems showing fluctuation of the same magnitude which quiet down on reaching a state of equilibrium make it quite evident that this same technique is reliable to this degree of precision. Therefore mechanical manipulation of the system cannot account for these fluctuations*.

Fluctuations of the same erratic character were also recorded with ethyl alcohol, although with a smaller amplitude. Fluctuations were observed in ordinary distilled water, although they were not as large as those of the solutions of aluminum sulphate.

It appears at the present time that the amplitude of the fluctuations is somewhat correlated with the length of the chain in an organic compound. Thus the effect is much more pronounced in isoamyl alcohol than in ethyl alcohol; and it is still more moderate in water, (which may be regarded as an alcohol in which the chain is replaced by hydrogen).

The initial experiments with water showed exactly the same erratic variations which suggested that the effect cannot be due to experimental errors. However, it was too small to convince readers. Some people expressed the view that such work can become convincing only if confirmed by the Bureau of Standards. When it was found that the effect can be magnified to the extent of exhibiting fluctuations in the third or sometimes even in the second decimal place for certain systems, it became obvious that it can be put into evidence by means of an ordinary analytical balance. It was also said that the changes of atmospheric pressure can be responsible for it. This is not excluded in the sense that it can give an impetus to some changes, but there was no observed correlation of any kind between the zig-zags of the curve observed and changes of barometric pressure.

Theory

The fluctuations are a strong evidence in favor of the theory of aggregates. Under the van der Waals concept they could not take place. The theory of aggregates was given in a previous paper[2] published in this journal. The main result of it was: *"vapor and liquid in equilibrium contain an equal number of particles per unit volume."* The aggregates in liquids are enormous at low temperatures. They exhibit the Tyndal effect and often can be put into evidence by means of an ultramicroscope; in magnitude and other characteristics they approach the colloidal state. In such case the fluctuations can be visualized, which is not possible when matter is molecularly dispersed. The transfer of an aggregate into the vapor phase across the surface must be like a volcanic eruption. The fluctuations have not yet been observed in vapor pressure. However, in two-phase systems with small solubility, in the layer with higher surface tension one can observe fluctuations in capillary measurements. However, the drop method does not show these effects. Apparently the fluctuations observed within the narrow capillary average themselves out in a broad surface in the drop experiment.

* The liquid from the bottle kept in the thermostat was always transferred into a pycnometer by means of a hypodermic needle.

All the relations in the paper[2] are accurate because they are based on the concept of equilibrium, subject only to probability variations, which may be appreciable.

It should be also made clear that this theory rests on the assumption that the gas laws are valid in liquids (an assumption for which there exists considerable favorable evidence). The apparent deviations from them are due to the formation of aggregates and not to van der Waals attractions, as is often postulated. This can be made clear by an experiment with a greased needle, which can float on the surface of water, being held by surface tension forces. Once forced inside the liquid it is under the effect of no forces, because forces acting on it in opposite directions are balanced and thus cancel each other. The same idea may be applied to aggregates. If we picture the kinetic behavior of liquids in terms of aggregates, and not simple molecules, the gas laws show themselves perfect. To the same conclusion arrived the French scientist Duclaux[4].

This theory will show itself particularly useful for the biological sciences, because living organisms contain water or its solutions as their chief constituent.

This theory enounces a general principle as important for the liquid state as was the Avogadro law for gases. ●

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★ ★ ★ ★ ★

"It is not by mere accident that, in general, the strongest colleges of liberal arts, with the highest standards and fidelity to the idea of a liberal education, should be the privately supported ones, whose roots reach down to a more classical past and whose founders were sensitive to human and spiritual values above and beyond temporal considerations."

—Harold W. Dodds, *Pres., Princeton University*
The Liberal Arts—A Challenge to Communism
Assn. of American Colleges Bulletin, August '49

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"The reward without the quest, the prize without training for the race, Heaven without probation, wages without work, a master's prestige without a master's skill, a trade without an apprenticeship! How much our secondary-school educational practice is a reflection of the current American desire to obtain by affirmation instead of by hard labor or how much that absurd expectation is the result of secondary education as we have it, would be difficult to determine; but that the two have a connection seems plain enough."

—Bernard Iddings Bell
Crisis in Education

Nutrition Education in Secondary Schools

● **By Elizabeth A. Lockwood, Dr.P.H.,** *(Harvard University)*
FIELD CONSULTANT IN HEALTH EDUCATION, NATIONAL FOUNDATION FOR INFANTILE PARALYSIS, NEW YORK, NEW YORK

America's health suffers because Americans haven't learned how to eat.

Sound information regarding diet and nutrition should be included in the daily lessons of all pupils from kindergarten to college. Teachers should cooperate. They must have accurate basic information. This can be gained through preservice and inservice training.

Dr. Lockwood suggests various ways in which school departments may unite in stimulating students to improve their dietary habits. Four "C's" are necessary for success.

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Country-wide stressing of better school health programs has brought an increased realization on the part of educators, scientists and physicians that Americans are far from being as healthy as their optimum would permit. While most Americans have the knowledge necessary for better health habits, they do not put into practice what they actually know. This is particularly true of information relative to diet and nutrition.

No American went through World War II without becoming food-conscious. Continual emphasis was placed on eating basic foods, particularly more vegetables, fruit and dairy products. As a result, people did eat better, from a health standpoint, because they thought they were contributing to a Cause by so doing. Yet today the average American has backslid, returning to the prewar food habits that had been instilled in him by family and community associations. Consequently, the children of such families are not eating as well as they should—and as they could.

How then can we build a generation of people that will eat naturally the wide variety of vital foods necessary for their health needs?

Since this is an important educational problem, it is possible that the schools might be more successful than the homes and communities have been up to now. By incorporating daily nutrition education into the school curriculum in the same manner we have included other needs for learning, schools could instill and emphasize good food habits from preschool days through high school. This means a long term program. However, no educator thinks it possible for a child to acquire mathematical skill, or reading ability and comprehension in one term. So why should we expect a child to acquire sound health and diet information in a few lessons?

Health and nutrition education should have continual emphasis through all grades from kindergarten to college—not as a separate course, nor by special teachers, but included as part of the regular curriculum by the regular daily teachers. Only then will diet and nutrition become a habit-pattern that actually affects daily living. Such hoped for, long-term goals necessitate, of course, that the teachers themselves be given an opportunity to obtain accurate basic information regarding diet and nutrition, and that they be shown methods and techniques for getting this information across to the pupils. This means preservice and inservice training.

Secondary school teachers have a real responsibility in aiding such a program since the majority of high school graduates go directly either to jobs or to home making. Many times the high school misses this final opportunity to affect the student's future way of life. Only a few pupils out of the total school enrollment take the usual home economics courses, which include diet and nutrition information. Those who do take such courses learn about the preparation of food and balanced meals, but their numbers are small.

Some high schools have a separate course in health education, which include units on diet and nutrition. Often, this is required for one term only. It is a one-day-a-week course, which means that the personality of the teacher will be the deciding factor as to whether or not much carry-over occurs, resulting in actual change of health habits. Also, a course in health education is neither standard nor usual throughout the country.

How can secondary schools impart adequate information, and also stimulate an improvement in food habits in such a way that they will remain improved? In reality, every high school now does a great deal of nutrition education, but it is unrelated, and rarely coordinated or cooperatively planned. Every teacher in each area of the curriculum has a part to play, and can assist in the planning, if he is made aware of the over-all purposes of the program. Such awareness calls for a total planning of all school departments—health, science, social studies, home and family, English, business science, mathematics, etc., with the school lunch room manager a core resource person. When everyone on the faculty realizes that there is need for more adequate information as well as activities for students leading to better health and nutrition, then planning can take place concerning the "hows" and "wherefores."

How can an administrator arouse his faculty to understand the need? Or how can the faculty obtain the backing of their administrator? An accurate picture of the dietary habits of the students is the best stimulator. Are students skipping, or eating inadequate breakfasts so that a normal body reaction and letdown comes about the middle of the morning? Are irritability, drowsiness, and inactivity, common occurrences in the third and fourth hour classes? If so, are these the result of poor dietary habits, or due to other causes? If students are permitted a choice of foods in the school

cafeteria, do they choose poor meals or good ones? Are too few balanced hot-lunches being purchased? Are candy and other packaged goods made so readily available that they compete with vegetables and fruits? No one can give the correct answers until the faculty and the lunchroom manager cooperate and make a factual check.

Are evening meals limited or being omitted, in spite of the fact that this is supposedly the main family meal? If students work after school, or if the family have their main meal at noon-time, this may often be the case. Are home meals low in vegetables, fruits and dairy products? In only a few sections of this country are meats or their equivalent ever lacking in the diet, and rarely are cereals and grain products low in consumption. However, Maine or Florida, California or Tennessee, Illinois or Pennsylvania, all find the same story regarding an inadequacy of green and yellow vegetables, citrus fruits, and dairy products. But a school faculty or administrator should not state that this is the case in his community unless he can support his statement with proven facts. A total school survey of three or four days' diet-intakes of the students will furnish such data*, and supply excellent ammunition for planning a program.

The second step in attaining a desired program is for each department of the curriculum to discuss what phases it is contributing and can contribute to an overall school nutrition education program. This can be hastened by checking the outlines or courses of study to discover the phases of nutrition education that are being, or can be, covered. Each department has many opportunities to aid.

Is there a functioning health education course taught by an energetic teacher with personality and ability who will let the students participate in the planning and organization of the course? If such a course is taken by *all* the students, *each year*, nutrition education will already have been emphasized. (If such a course is really functioning, the vital need for a concentrated school program in nutrition education has probably never arisen!) However, such health education courses are rare. What then can the other curricular divisions do?

Science—general science, biology, hygiene and physiology—can contribute a major part. Accurate and up to date information about food nutrients; the human body's needs and its reactions to food; metabolism; relationship of adequate and inadequate diets to daily living; physical, social, emotional, and even mental, relationships of food, nutrition and health—all these can be discussed.

However, successful appeal to an adolescent cannot be made through emphasizing the eating of specific foods because they are good for one, but rather through the personal appeal of adolescent problems, such as strength and endurance for athletic teams, clearer skins and complexions, loss of extra fat, or gain of weight for extreme thinness, more pleasing personalities because of better health, etc. These are personal, and practical, problems. A keener awareness and perception as to what food does for his body can change a student's well established pattern of food intake, and send him on into adulthood with a better opportunity for living a longer, more useful life.

Conservation is one area of science that also may be considered in social studies. There are many scientific and social implications relative to conservation problems that can be stressed in a health and nutrition education program. Some of the questions to be answered are: What is the future for a country that exploits her soil—and thus her crops? What is the relationship of water supplies to food supplies? Will our soils support adequately half the world's population and the American people as well? Do we have conservation policies and laws protecting our land?

Consumer education may cut across several branches of the curriculum. Schools have done too little to acquaint students with better buying knowledge, with an appreciation for the need of state and federal legislation regarding food and its transportation, sanitation, consumption and protection. More buying power and more money do not necessarily mean better food and a more adequate diet. Are our schools teaching all this?

Learning to proportion properly the budgeting of food supplies to other costs of living is a phase that can be emphasized in business science or in mathematics classes. Charts and graphs of the results of the diet surveys may be another contribution. Figuring percentages of the numbers of students eating basic food groups, or adequate and inadequate diets, can be done for classes, grades, and for total school enrollment. This is practical arithmetic.

Home and family living courses—or home economics—contribute opportunities for first hand application of the knowledge regarding food nutrients and balanced diets gained in science and health education. The increasing trend to have boys' classes in home economics is commendable, but the percentage of enrollment is meager.

There are many more possibilities for all branches of the curriculum, which can be brought to light by round-table discussions of the faculty. After each department considers its opportunities and possibilities of including practical nutrition education*, then the entire faculty and administration can plan a coordinated and concerted program for the school as a whole. An active school health and nutrition education com-

(Continued on Page 73)

* Such a diet survey and a simple tabulation were worked out by the author as a part of the school health and nutrition education programs sponsored by the Department of Nutrition, Harvard School of Public Health, Boston, Mass., in Newton, Mass., and in Rutherford County, Tennessee.

* The publication, *Goals for Nutrition Education — Kindergarten Through 12th Grade*, will suggest aims for all curricula. It may be obtained from the Nutrition Foundation, Inc., Chrysler Building, New York, N. Y., at 15c a copy. Lists of Teaching Aids for Biology, Social Studies, Home Economics, Health Education, Lunchroom, and a Film Bibliography for Secondary Schools, also are available from the Department of Nutrition, Harvard School of Public Health, 695 Huntington Ave., Boston, Mass. Teaching Aids are 10c each, the Film Bibliography is 50c.

Instructional Tools Must be *Used*

● **By George E. F. Brewer, Ph.D.,** *(University of Vienna)*
HEAD, DEPARTMENT OF CHEMISTRY, MARYGROVE COLLEGE, DETROIT, MICHIGAN

Realizing that instructional tools are valuable only to the extent to which they are actually put into service, the faculty of Marygrove College made a survey of the several departments to determine what teaching aids were currently available, how they were being utilized, and in what ways their use might be extended.

The results of this interesting self study are reported by the head of the department of chemistry as Chairman of the study group.

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Short of teaching itself, it is the foremost duty of the instructor to gain information on new developments in his field, both regarding the advances in the field and the possibilities of new techniques of presentation. The past two decades have seen a rapid development of teaching aids. World War II with its Army and Navy teaching programs, and the effort of industry to train employees, also accelerated the development of new teaching tools.

The Problem

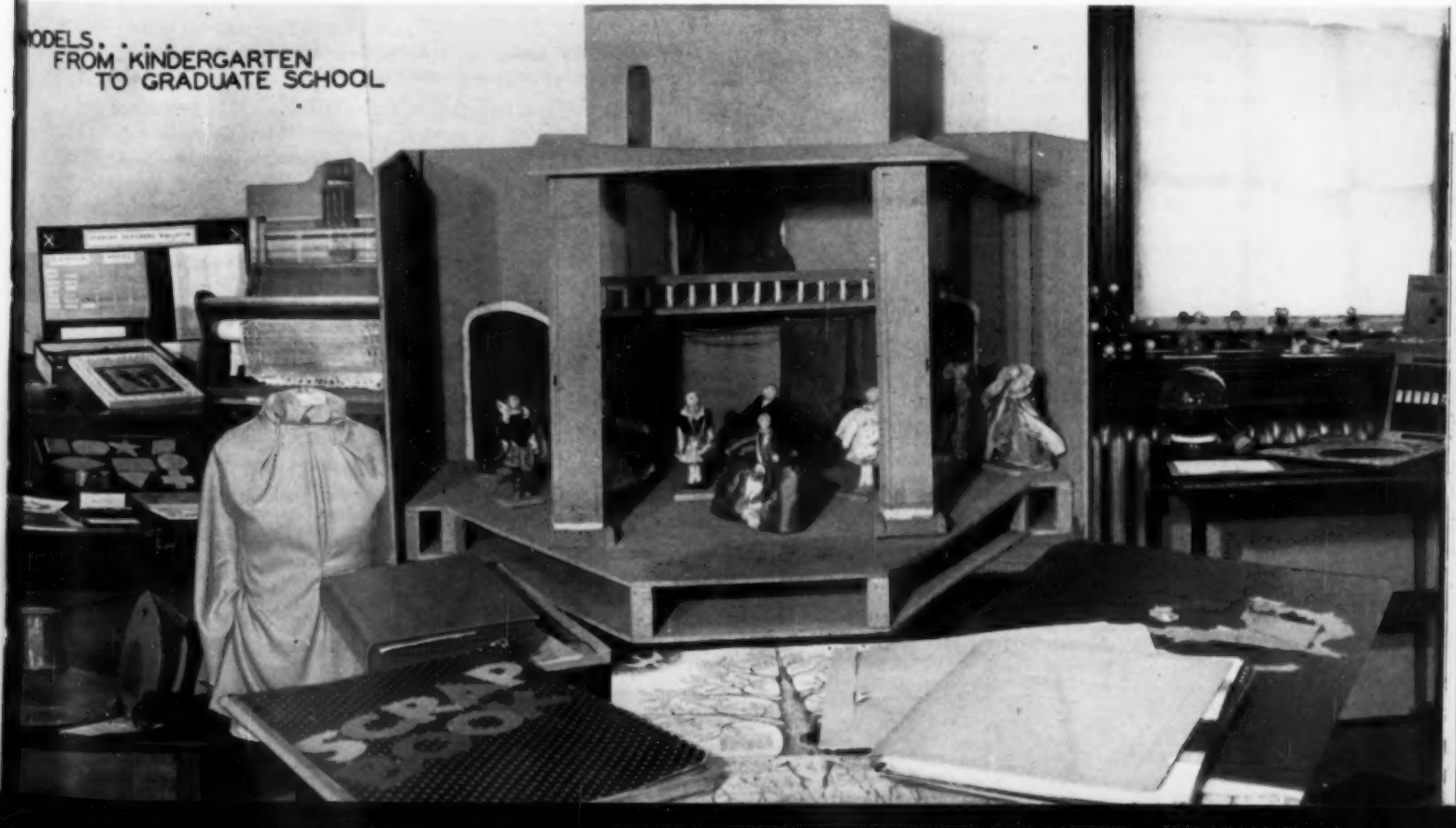
Because of their heavy teaching loads it is doubtful whether the development of teaching aids has been appreciated fully by schoolmen. It seemed, therefore, advisable to compare our own college's inventory of "tools" with that of other institutions; also to consider the possibilities of organizing the use of equipment by several departments whenever such sharing of facilities is feasible; and finally, to focus the interest of the faculty on teaching aids.

Technique of the Self Survey

The faculty formed a study group or committee consisting of fifteen members taken from a wide variety of departments. The first task of this group was to classify the tangible tools into the following groups and subgroups.

1. Books
   - *a.* Library
   - *b.* Textbooks
   - *c.* Work books and collections of problems
   - *d.* Syllabi and outlines
   - *e.* Manuals
   - *f.* Pamphlets, clippings, newspapers, and other printed material
2. Audio-visual Aids
   - *a.* Films
   - *b.* Records
   - *c.* Charts, graphs and maps
   - *d.* Demonstration material
3. Work Shop and Laboratory
4. Campus Buildings, Class-rooms, Furniture, etc.
5. Facilities off Campus

The members of the study group collected data from the various departments regarding each group and sub-



group. Three main points that were answered for every item:

A. Whether such tool is existing at all in the field of each department, and if not, what chances there may be to develop it.

B. Whether the item is existing in the college in satisfactory quality and sufficient numbers, and the reasons which would prompt us to acquire it, either by buying it or making it.

C. To what extent the item is already in use, what more extensive use could be made of it, or the reasons for the advisability to curtail its use. Finally, any suggestions as to what other department could make use of this tool.

Since well over twenty departments reported to the study group, the evaluation of the reports was no mean task. As a first step, findings were tabulated like the example given below.

Evaluation Chart

TOOL	DEPT.	ON HAND	DEVELOPED BY OR FOR OTHERS	USED HERE	REMARKS
2c Charts, graphs and maps	Biology	Almost complete line of commercially available material and numerous "home made" ones	Yes; much material existing in elementary and secondary school level; would like suppliers to offer more on college level	Constantly	The most complete type of audio-visual aid used in this dept.
2c Charts, graphs and maps	Physics	A limited number of good charts on hand	Yes; we intend to assemble some material	Moderately (see remarks)	A projector for opaque material needed that can be operated by instructor without leaving the front of the room

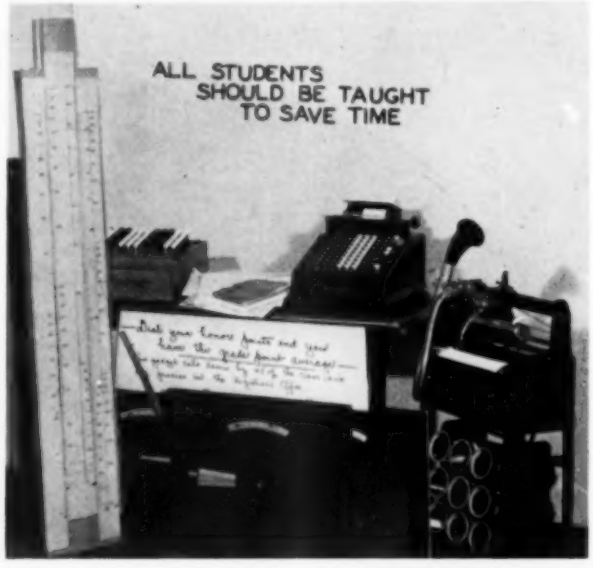
These tabulations were then evaluated from the following points of view:

A. To try to find the general pattern of the departmental reports. That is, to find out whether deficiency or satisfaction with a certain tool is pointed out by single departments, or whether a whole group of departments (for instance, all the "arts of communication") voice a uniform opinion.

B. What departments or groups of departments are making most, or best use of some tool, and what departments are making least use of the tool.

C. Whether unusual or new uses are pointed out.

D. What suggestions are made in the departmental reports.



Results of the Self Survey

1) A clear picture of the departmental needs for teaching aids was formed, so that the administration might be able to take the necessary steps in budgeting and supplying the departments.

2) Cooperation of departments in the sharing of equipment was organized.

3) Vague plans for the development or assembling of teaching aids took on a definite shape.

4) The best results, however, will come from the interest in teaching aids which has been aroused in the faculty members.

5) The exchange of ideas between instructors was facilitated by an exhibition of home made and commercially available tools. The "exhibitors" demonstrated those of their favorite gadgets and techniques which they thought would be useful in a variety of fields. ●

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Synthetic Gasoline

● **By Reginald G. Sloane, Chem. E.,** *(Columbia University)*
STANDARD OIL COMPANY (NEW JERSEY), NEW YORK, NEW YORK

This is a calm and frank appraisal of the current situation in the petroleum industry and of the outlook for the future.

Some day we may have to distill tar sands and oil shale or prepare synthetic fuels from natural gas and coal. We already have the know-how to design plants for the manufacture of substitute liquid fuels. But the continued extension of our petroleum reserves and improvements in production methods should provide for our normal needs for a long time to come.

●

Within the ninety-year span of the commercial life of petroleum, passenger cars, buses, trucks, and airplanes have become indispensable to existence in almost every community in the world. In the United States alone, these forms of transportation require over three-fourths of a billion barrels of gasoline each year.

The 35,000,000 passenger cars on the road in this country average over 10,000 miles of travel within a year; and a smaller number of buses each averages three times this distance. All these are dependent upon liquid fuels. Automobiles have been run on wood, on gas, and on other substitute fuels where gasoline was not available, but not without a great sacrifice in convenience and efficiency; and such substitutes scarcely seem adapted to practical airplane propulsion. In view of the importance of liquid fuel to modern transportation, it is not surprising that some concern has been expressed over the continued supply of this vital fluid.

Figures on petroleum supplies most likely to come to the attention of the public are those on proved reserves. The American Petroleum Institute reported proved reserves of the United States at the end of 1949 to be 28 billion barrels, including liquids such as natural gasoline associated with natural gas. The total domestic demand for petroleum products amounted to about two and one-fourth billion barrels. At this rate of consumption, proved reserves were equivalent to about 12 years' supply.

But proved reserves represent only discovered oil, the underground working stock of the petroleum industry. They are continually being supplemented by new discoveries, and, of course, drawn upon by current production. They are but a fraction of our total petroleum resources. And today, proved reserves are at a higher level than they ever have been. Nevertheless, the petroleum industry in its long-range planning includes active study of possible substitute sources of liquid fuels in anticipation of the day when petroleum will be unable to supply the full demand, or when the cost of finding and producing petroleum rises to where other sources become competitive with it. The principal sources of substitute liquid fuels now envisioned are tar sands, oil shales, and synthetic products from natural gas and coal.

The Athabaska tar sand deposits of Canada are the largest of the tar sand deposits. Others are in Utah and California, with smaller ones in Alabama, Kentucky, and Oklahoma. Together, the United States deposits are estimated to represent a potential gasoline reserve of about 3 billion barrels.

Tar sands are composed of sand particles stuck together into a compact mass with tarry material. The material is related to petroleum and can be removed from the sand by washing with hot water or oil, or by simple distillation. The oil produced is heavy and of poor quality compared to ordinary crudes and requires further treatment before it is ready for conventional refining. The cost of gasoline prepared from tar sands will naturally vary with the depths from which the tar sands have to be mined and with their oil content. Strip mining or quarrying of rich sands should produce a gasoline which at best would have to be marketed at several cents above existing service station prices, and most tar sand gasolines seem likely to require prices substantially above these levels.

Domestic oil shales are far more extensive than tar sands, their recoverable oil content running to something like 250 billion barrels. The expense of mining and the complicated refining required will probably make shale oil also an expensive substitute source of gasoline.

Oil shales are hard slate-like rocks generally having greenish-brown veins of greasy material. When crushed and heated, the shales give off hydrocarbon vapors which are condensed to crude shale oil. This oil can be refined by processes similar to those used for petroleum, although, like the raw oil from tar sands, it requires preliminary treatment before it can be refined in the conventional manner. Shales of Colorado and Utah average about twenty-four gallons of oil to the ton, with many of higher oil content. A recently developed room and pillar method of horizontal excavation from outcrops of the 75-foot seams available promises low mining costs. Kentucky and Indiana deposits are leaner —less than 15 gallons to the ton—and are in their seams at some depth, requiring more expensive mining. California shales lie among oil fields and yield about 20 gallons of crude oil to the ton.

While tar sands and oil shales represent sources of substitute liquid fuels, synthetic liquid fuels are really those derived from coal and natural gas respectively through conversion by chemical means into liquid hydrocarbons such as are found in petroleum.

The hydrogenation process, wherein hydrogen is added directly to a substance, had been known to chemists for a long time. It has been applied commercially to vegetable oils for making butter substitutes and shortening. In this process a catalyst, consisting of nickel, platinum, or some of the other rare metals, was required to carry out the reaction. Hydrogenation of coal appeared to be a logical way of converting the solid carbon of coal into liquid hydrocarbons. However, the process was unsuccessful because the sulfur in coal poisoned and deactivated the catalyst.

Deficiency in petroleum supplies early spurred Germany into looking for alternate sources of liquid fuel. Research started by Dr. Friedrich Bergius in 1910 culminated in the construction of a successful coal hydrogenation plant in 1924. By substituting iron oxide for the other types of catalyst, poisoning by sulfur was overcome, and coal could be liquefied to yield products similar to those derived from petroleum. Chemically, the primary difference between coal and petroleum hydrocarbons is the higher hydrogen content of the latter. A hydrogenation process successful with coal is, therefore, applicable also to petroleum. The Bergius process for petroleum hydrogenation was brought to the United States by Standard Oil Company (New Jersey) in 1927. Originally intended for improving lubricating oils, modifications of the process yielded synthetic toluene from petroleum for the manufacture of TNT and high octane components of 100 octane aviation gasoline during the war.

Coal hydrogenation on a commercial scale has been employed in plants abroad, notably in Germany and England. The only plant in this country is the Bureau of Mines demonstration plant at Louisiana, Mo. The Bureau of Mines employs a two-stage process. In the first stage a paste of pulverized coal, iron oxide catalyst, and recycled heavy oil is exposed to hydrogen under 10,000 pounds per square inch pressure at a reaction temperature of 900° F. for liquefaction of the coal; and in the second stage the product obtained is subjected to hydrogen under similar conditions in the presence of a catalyst composed of fuller's earth treated with hydrofluoric acid and impregnated with zinc, molybdenum, chromium, and sulfur, to yield gasoline and other products.

The high pressures required in the Bergius process call for heavy equipment and a large outlay of steel for plant construction. Cost estimates indicate a higher investment and operating cost for making gasoline by hydrogenation than by the newer Fischer-Tropsch process.

Drs. Franz Fischer and Hans Tropsch, working in Germany, recognized the possibility of converting a mixture of carbon monoxide and hydrogen — essentially water-gas—into liquid hydrocarbons. The carbon monoxide-hydrogen mixture was made by partial combustion of coal in the presence of oxygen and steam. Following intensive research starting about 1925, Fischer and Tropsch succeeded in accomplishing the synthesis, and construction of a plant for converting coal to liquid products by their process, with a capacity of 1,000 tons of oil per year, was started in Germany in 1933. Subsequently the process was greatly expanded in that country.

For the United States the Fischer-Tropsch process would be applicable not only to coal but to natural gas as well. Either one, by controlled combustion can be made to yield the carbon monoxide and hydrogen in proper proportions for so-called synthesis gas, the raw material for conversion into liquid hydrocarbons. In the case of natural gas only oxygen is used in the combustion, whereas with coal both oxygen and steam are used. An important consideration in planning a Fischer-Tropsch plant is the production of an adequate supply of oxygen. Considerable progress has been made in recent years in oxygen manufacture, and some plants are now producing oxygen from air on a tonnage basis. Nevertheless, oxygen production represents a major cost item in the hydrocarbon synthesis process. A 10,000 barrel a day synthetic oil plant would require about 75,000,000 cubic feet of oxygen daily.

The conversion of synthesis gas into liquid products as it would be carried out in this country would incorporate modifications of the Fischer-Tropsch process that have been developed here, leading to many engineering and operating economies.

The process consists in passing purified synthesis gas through a reactor in which it comes in contact with an iron catalyst at a temperature of around 600°, F., under a pressure of about 400 pounds per square inch. In the reactor the conversion to liquid hydrocarbons takes place. One feature of this conversion is the enormous amount of heat generated. Keeping the temperature down to the proper level in a German-type plant producing 10,000 barrels a day of liquid products would require some 6,000,000 square feet of cooling surface. And such a plant would have 128 reactors. American developments permit reducing the cooling surface to 20,000 square feet and the reactors to four. The liquid products from the reactor are separated into gasoline, heating oil, and other products. Among the by-products of the process are numerous valuable oxygenated chemical compounds.

Investment and operating costs favor hydrocarbon synthesis from coal or natural gas, over coal hydrogenation. Numerous estimates have been given of the costs of liquid fuels from various sources. Costs depend upon so many variable factors—cost of raw materials, location of plant, return on investment, etc.—that two estimates seldom agree. Apparently synthesis from coal would cost 19-23¢ per gallon, with comparable gasoline from petroleum at around 12-14¢ per gallon. Cost of production of gasoline from natural gas is more favorable and nearer to that from petroleum.

One commercial hydrocarbon synthesis plant is under construction in this country. Located at Brownsville, Texas, this plant owned by Carthage Hydrocol, Inc., will utilize natural gas as raw material and will have,

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The Teaching of Science Courses for General Education

● By **Sister Mary Grace, Ph.D.**, *(Catholic University)*
PROFESSOR OF SCIENCE, GEORGIAN COURT COLLEGE, LAKEWOOD, NEW JERSEY

A recent significant development in science education is the institution of college courses designed to further the general education of the non-science student by giving him a better understanding of science and scientists. Pioneering Harvard now offers courses designed "to mediate between laymen and scientists, between a classical and a scientific civilization."

Sister Mary Grace spent last Summer at Harvard observing and participating in the courses now in operation. Here is her description of the work being done.

●

During the summer session of 1949, Dr. James Bryant Conant, President of Harvard University, directed and personally participated in a unique type of course concerned with the problems of science in general education. Working in collaboration with Dr. Conant were Dr. Earl J. McGrath, United States Commissioner of Education, and editor of the book "Science in General Education"; and Professors LeCorbeiller, Kemble, Cohen, Watson and Nash, who are faculty members engaged in the pioneer work being carried on at Harvard to further general education in a free society. The class comprised fifty men and women, for the most part Ph.D's who were already conducting science courses in general education, or who were interested in establishing such courses in the near future.

The need for science courses of this kind became evident during the war years when close collaboration between scientists and laymen revealed the presence of barriers between them. Although these were evident during periods of comparative quiet, they became intolerable at a time of great stress and national emergency. The laymen and the scientists did not speak the same language, despite the fact that this is a scientific age, and that scientists hold the controlling knowlege and skill in industry and in matters that affect the whole policy of commerce and government.[1]

Though statistical evidence is not at hand, it is safe to assume that many of the laymen participating in wartime projects had once been subject to the orthodox courses presented in our schools, and that after the passage of a few years little remained that would indicate a feeling for or an understanding of either science or scientists. A few believed science to be the cause of all the evils of the world, a few the panacea for all its ills, but a vast majority of the laymen assumed an attitude of complete indifference.

Since in our present high school and college classes we find our future statesmen and legislators, it seems essential that we use even drastic measures if need be to give these future administrators the knowledge necessary for them to act wisely and with some measure of certitude in matters of science.

To answer this need, courses in "Science in General Education," have been established in various colleges and discussed in conferences initiated by President Conant of Harvard, Dean French of Colgate, Dean Taylor of Princeton, and many other leaders in education.

A survey of the courses of this kind offered in colleges and universities in the United States was discussed in the Harvard course S51 by Commissioner McGrath and the professors participating in the undergraduate courses in General Education. Their plans, and their successes and failures as they saw them, were presented for the consideration of the class. All the courses under discussion had been planned for that vast majority of students who will not concentrate in the field of science, but who need to have developed (1) the ability to analyze statements about methods of science, (2) the ability to analyze statements about research projects, (3) the ability to discuss intelligently the organization of science and the relation of science to intellectual history. An important outcome of such courses should be a continuing curiosity about science and its applications, and a desire to acquire a solid knowledge of a variety of instances in which the methods of science have yielded results. This is what Dr. Conant means when he states, "The prime object of the course is to give the student such an understanding of science that in his subsequent study and reading he will relate his knowledge of the subject to the other aspects of his college education."[2]

To quote Eric Rogers, these courses " . . . . . aim at producing sympathetic non-scientists who understand something of the nature of science, who feel they know what scientific work is like and what scientists are like, who have seen experiment and theory and critical argument used in building the structure of knowledge."[3]

Harvard offers four courses in the physical sciences for the non-concentrator, which though they differ in content attempt in some degree "to mediate between the laymen and scientists, between a classical and a scientific civilization."[4] In one course emphasis is placed on the manner in which science permeates American life. The course was discussed by its originator, Professor LeCorbeiller. It is designed for students with little science preparation who desire to obtain a background for understanding our technical civilization. To quote Professor LeCorbeiller, "If a girl wants to be a social worker rather than count electrons, she is right,

But as a university graduate in a community she will be asked, 'What do you think?' and she cannot answer, 'I don't know, I was an art major'."

In the first semester Professor LeCorbeiller covers aspects of physics, chemistry and geology in relation to industrial power as seen in practical use in the automobile; the following semester term is more concerned with the type of power as exemplified in the atomic bomb. The advantage of the course lies in its ability to stimulate student interest, to form a background for interesting discussions, and to overcome a natural antipathy so often found among non-concentrators in science. The disadvantage may lie in the tendency of the course to become either too technical or too vague.

Like the foregoing course, a second one, also designed for students with but little scientific preparation, has been inaugurated. But here great stress is placed on historical background, on the personalities of the scientists and the philosophic implications of major scientific ideas. Readings of the great scientists are assigned in the original, as well as books devoted to the history of science and intellectual history. As outlined by Dr. Cohen, this course is designed to foster a close relationship with the other courses taken by the student. In fact it was suggested that recognition be given by the English department for well-developed topics, and by the foreign language department whenever meritorious translations are made by the student. Strangely enough, one of the difficulties of administering the course lay in the paucity of good translations available to the student for reference material.

Two other courses are designed to meet the needs of students who have studied high school physics and mathematics. One of these presents concrete scientific problems with physics as the core. It begins with Babylonian astronomy and ends with the nuclear chain reaction. It includes a discussion of the impact of scientific ideas on the social order of the 17th and 18th centuries. In its latter part the course becomes less historical and concentrates on the structure of matter. One obvious advantage in the course is that only the better type of student will be found in it, and this is encouraging. The aim is to give the student training in logical thinking, respect for disinterested inquiry, and an objective experimental attitude toward problems requiring a scientific approach. The disadvantages are the time limit and the absence of complete reference books.

A fourth approach to the solution of the problem of science in general education is President Conant's famous case history approach, which resembles the block and gap procedure of Professor Rogers of Princeton. The plan is to select certain meritorious cases which illustrate well the strategy and tactics of science. These are studied in somewhat the same manner that potential lawyers and business administrators study representative cases. The actual handling of the cases requires careful planning, but very little emphasis is placed on memory work. The ability to comprehend scientific generalizations and to handle scientific concepts is paramount. Some cases considered in this course were: The 17th century development of pneumatics, with special reference to the work of Robert Boyle; the overthrow of the phlogiston theory, with special reference to the work of Priestly and Lavoisier with oxygen; and Pasteur's work on spontaneous generation.

In order to qualify as a case, the material must be gathered and briefed and the basic documents collected and edited. In many cases this has been found laborious and time-consuming since the material must be carefully and copiously annotated unless one is satisfied with a superficial reading or is prepared to go over the documents line by line in class.

This method has the advantage of going deeply into the aspects of various sciences and giving a much more logical picture than is obtained when one is restricted to a certain field such as chemistry. Referring to the Pasteur case, Dr. Conant states,

> "Pasteur's writings show the statistic and strategical thinking of a great man, he is stubborn until proven wrong, his knowledge at times seems almost intuitive, he illustrates well the saying 'it pays to have enemies in science' and his work is sufficiently recent to appeal to the modern mind. Simultaneously, the student is learning the state of research in France at this time and the effect national pride has on a scientific project."[5]

By noting the recurrence of such phenomena in science the student observes the difficulties encountered by the experimenter and sees why when faced with a problem one man succeeded, and another failed.

In a course of this type where intensive work is done on certain cases, much less material will be covered than in the orthodox course, but the student should emerge from such a discipline with a better appreciation and understanding of science than factual knowledge can give.

Another criticism is that jumping from one science to another confuses the student; but it must be pointed out that there are no such boundaries set by the experiment when the student is seeking truth. To understand science, the learner must follow the trail even when it cuts course boundaries.

The study of case histories is supplemented by a series of lectures on the history of science and its methods, and there are numerous assignments in collateral reading. The discussions that flow from these form the strongest link between the cases. They give the student time to look back and survey the path over which he has come, and to correlate it with his knowledge from other fields.

At this time, it is difficult to evaluate the types of courses we have described since they are all taught with the idea of developing laymen who understand science and scientists. The training of enthusiastic inspired teachers, the documentation and evaluation of original sources and secondary sources, the planning of examinations to test adequately the work covered, are

(Continued on Page 78)

Stainless Steel--Modern Metal

● **By Richard E. Paret**
STAINLESS STEEL SPECIALIST, AMERICAN IRON AND STEEL INSTITUTE, NEW YORK, NEW YORK

A truly modern, almost corrosion proof metal of great value and of wide and growing usefulness is described in this paper.

Stainless steel is not a single product. More than a score of such steels are in common use. Their properties may be adjusted almost at will.

Fabricators and metal workers continually find new applications for this versatile material that has already revolutionized many industrial procedures.

●

Stainless steel, a new "noble" metal, has become common only recently. Pioneering metallurgists put chromium in iron over a hundred years ago, and some of their alloys resembled modern stainless steel. However, largely because their metals also contained carbon in substantial amounts, they did not recognize the potential corrosion resistance, the beauty, or the general utility of the alloys they were creating.

It took until the early 1920's for stainless steel to reach commercial importance. By then stainless cutlery had established a market, which continues to expand today. The entire nitric acid producing industry was revolutionized because, for the first time, production could take place in metallic equipment. Nitric acid attacks ordinary steel, brass, copper, etc., with destructive effect, but it can be handled safely in stainless steel. Chemical industries, the oil industry, refiners handling corrosive crudes, and many other continuous process operators have since discovered its usefulness.

In the architectural field, pioneers saw a chance for improvement and selected stainless steel to withstand the onslaughts of the weather on the world's tallest buildings, the Chrysler Building and the Empire State Building. From that start, stainless steels have become an accepted architectural material for beautifying, saving weight, and cutting costs of all sorts of structures. Today, the stainless steel is used for trim, ornamentation, and structural members, and as curtain wall panels to replace masonry on modern buildings.

The ease with which stainless steel can be cleaned and kept sanitary has created a tremendous demand for it in restaurant kitchens, in the dairy industry, and in most food producing and processing plants. The stringent sanitary codes of states and cities today, while they do not exclude other materials, make stainless steel the outstanding first choice.

An indication of the rapid growth in the use of stainless steel is its production record. From a few hundred pounds in 1915, production grew to 49,000 net tons in 1929, and then increased more than 12-fold to 617,000 net tons in 1948. During most of this period, stainless steels have accounted for a progressively larger percentage of the total American steel tonnage.

Because no single analysis of stainless steel can satisfy all the many technical and economic requirements of modern industry, there are today, some 27 stainless types in common use. Each belongs to one of three major classes: (1) chromium-nickel or Austenitic; (2) straight chromium or Martensitic (hardenable by heat treatment); (3) straight chromium or Ferritic (non-hardenable). The chromium-nickel grades are normally nonmagnetic; the chromium grades magnetic.

We distinguish the stainless steels from the non-stainless chrome steels by the amount of chromium alloyed with the iron. Only alloys containing at least 11.5 per cent chromium are classified as stainless. The most common stainless composition, familiarly known as "18-8", has 18 per cent chromium and 8 per cent nickel, with the rest substantially all iron. Nickel, added to the alloy, increases stainless steel's corrosion resistance slightly and makes it stronger and more ductile so that it can be more easily welded, cold worked, and formed into a great variety of shapes at room temperatures.

Alloying metals such as molybdenum, sulphur, ti-

THESE FOOD-PROCESSING EQUIPMENT PARTS will keep their gleaming stainless beauty—and their health-guarding cleanliness, through many years of service.

TABLE I

STAINLESS STEEL

INGOT PRODUCTION
(net short tons)

Year	Production	Year	Production
1929	49,000	1939	180,000
1930	55,000	1940	250,000
1931	31,000	1941	372,000
1932	24,000	1942	341,000
1933	36,000	1943	457,000
1934	56,000	1944	477,000
1935	74,000	1945	543,000
1936	102,000	1946	550,000
1937	157,000	1947	520,000
1938	96,000	1948	617,000

tanium, columbium, selenium and others may be included in small amounts to impart special characteristics to stainless types for specific uses. Sulphur and selenium, for instance, make the metal easier to machine. Molybdenum increases resistance to corrosion under severe conditions. Titanium and columbium make stainless steel more stable during welding. Carbon which is always present in some amount, may be controlled to gain specific properties.

To meet the exacting requirements demanded of stainless steel today, it is necessary to have complete control over the manufacturing process. High quality standards are rigidly maintained. The extra care that is taken in melting, cropping ingots, pickling for scale removal, chipping and grinding to correct surface flaws, and in continuous surveillance at all steps of its manufacture makes stainless truly a premium quality material.

A variety of melting procedures are commonly used for making the different kinds of stainless steels*. The basic materials are usually scrap steel plus ferrochromium, and nickel and ferro alloys of the other added elements. Electric furnaces are used because they afford excellent temperature and process control. Withdrawal of impurities as slag when necessary leaves the metal bath with the controlled composition desired. Then it is poured into castings or ingots for further processing.

A uniformly heated ingot, cropped to remove all imperfections caused by shrinkage, is reduced by pressing or rolling in preparation for further rolling or drawing. During these steps, each piece is examined repeatedly for flaws, and any imperfections are ground or chipped out. Sometimes the entire piece is rough machined before additional work is done on it.

The greatest portion of stainless production comes out of the rolling mill as sheets or strips (less than 24 inches wide). Other useful forms that are produced in substantial quantities are the structural shapes, plates, rods, bars, wire, welded or seamless tube, etc.

Such mill shapes are furnished either hot or cold worked, annealed or with special tempers to suit individual applications. Surface finishes range from a gleaming high polish to a dull "frosted" treatment. The surface may be as it comes from the last hot or cold rolling operation, or as pickled and annealed. Bars, rods and tubes with surfaces ground to precise dimensions are available.

Significant amounts of stainless steel go into castings or forgings. Fasteners, such as nuts, bolts, screws, washers, pins,

TABLE III

TYPICAL MECHANICAL PROPERTIES OF 18-8 STAINLESS, TYPE 302

ANNEALED	
Tensile strength, psi	90,000
Yield strength, psi (0.2% offset)	35,000
Elongation, per cent	60
Reduction in area, per cent	70
Izod impact, foot-pounds	110
Brinell hardness	150
Thermal exp. coef. (32 deg F – 212 deg F)	9.6×10^{-6}
COLD DRAWN — 40% Reduction in Area	
Tensile strength, psi	195,000
Yield strength, psi (0.2% offset)	165,000
Elongation, per cent	10
Rockwell hardness	C-40

TABLE II

CHEMICAL COMPOSITIONS OF THE MOST COMMON STAINLESS STEELS

Type Number	Per Cent Chromium	Per Cent Nickel	Other Elements
301	16.00/18.00	6.00/8.00	—
302	17.00/19.00	8.00/10.00	—
302B	17.00/19.00	8.00/10.00	—
303	17.00/19.00	8.00/10.00	P, S, Se Min. 0.07, Zr, Mo Max. 0.60
304	18.00/20.00	8.00/11.00	—
308	19.00/21.00	10.00/12.00	—
309	22.00/24.00	12.00/15.00	—
310	24.00/26.00	19.00/22.00	—
316	16.00/18.00	10.00/14.00	Mo 1.75/2.75
321	17.00/19.00	8.00/11.00	Ti 5 x C Min.
347	17.00/19.00	9.00/12.00	Cb 10 x C Min.
403	11.50/13.00	—	(Turbine Quality)
405	11.50/13.50	—	Al 0.10/0.30
406	12.00/14.00	—	Al 3.50/4.50
410	11.50/13.50	—	—
414	11.40/13.50	1.25/2.50	—
416	12.00/14.00	—	P, S, Se Min. 0.07, Zr, Mo Max. 0.60
420	12.00/14.00	—	—
430	14.00/18.00	—	—
430F	14.00/18.00	—	P, S, Se Min. 0.07, Zr, Mo Max. 0.60
431	15.00/17.00	1.25/2.50	—
440A	16.00/18.00	—	Mo 0.75 Max.
440B	16.00/18.00	—	Mo 0.75 Max.
440C	16.00/18.00	—	Mo 0.75 Max.
442	18.00/23.00	—	—
443	18.00/23.00	—	0.90/1.25 Cu
446	23.00/27.00	—	N_2 0.25 Max.

* The reader interested in a detailed discussion of stainless steel manufacture is referred to "Production of Stainless Steel," by B. H. DeLong, appearing in Oct. 31 and Nov. 7, 1949, issues of *Steel*, a Penton Publication, Penton Bldg., Cleveland 13, Ohio. These articles will comprise a chapter in a book, "The ABC of Iron and Steel," to be published during 1950.

rivets, nails and special devices are all available in a variety of grades of stainless steel from a number of fabricators. Such products as stainless screen, perforated sheets, stainless-clad mild steel, hardware and fittings can be obtained from many sources.

Making things of stainless—all the metalworking arts—can be carried out in much the same way as other metals are handled. Indeed, stainless steels lend themselves to all methods of fabrication that are common with ordinary steels.

Bending, riveting, forming, punching and spinning operations are widely used to make rigid structures of light-gauge sheet. Although the metal is stronger and resists deformation more tenaciously than most other materials, comparable articles can usually be made on the same types of equipment used for weaker metals. The reason for this is that thinner construction is adequate with stainless because of its high strength and because no extra allowance is needed to take care of corrosion's inroads.

Machining stainless steels tends to require slower speeds and rigid tooling, but is economically performed on all types of parts. Where high-speed screw machine production is desired, the free-machining stainless types come into use with substantial opportunities for savings.

Stainless steel can be welded easily by any of the common industrial methods. Extra-low-carbon types or the stabilized types may be used for high corrosion resistance in welded structures. A tendency of chromium carbides to form near the welds can be counteracted by annealing, by limiting the carbon or by adding small amounts of columbium or titanium which combine with carbon. These two stabilizing elements prevent diversion of alloyed chromium from its important job of maintaining a corrosion-resisting oxide film.

THE ENTIRE WALL of this circular staircase, including the hand rail, in the Terrace Plaza Hotel in Cincinnati is made of stainless steel.

General fabricators and small metal-working organizations throughout the country are gaining a familiarity with stainless steel as a versatile and workable material. As familiarity and skill increase, the widespread use of stainless steels in all manner of hitherto unexplored applications can be expected.

The present usefulness of stainless steels in so many places can be summed up in their three outstanding qualities: corrosion resistance, beauty, and high strength.

Both corrosion resistance and high strength are retained to a remarkable degree at high temperatures. This is unusual among metals, because loss of strength, creep, flaking, and scaling commonly limit the service temperatures of equipment made of the ordinary structural materials.

The substantial "creep strength" of certain stainless alloys means that the loads they can carry while hot, without harmful stretching or deforming as time passes, are high. This keeps high-temperature stainless equipment on the job after heat and stress have caused failure in materials with lower creep strengths.

While most metals waste away with a loose, flaking scale at high temperatures, heat resistant stainless develops an almost impervious black "armor" of hard oxide which endures temperatures as high as 2200° F. in some applications.

The corrosion resistance of stainless steels is generally ascribed to a very thin film of chromium oxide that forms on their surfaces. This film prevents air, water, chemicals, fumes, and a host of corrosive elements from attacking the steel itself. When scratched, the film reforms. As long as the surface is kept clean enough to allow continued uniform oxidation and repair of the film, and as long as the correct stainless type is applied to the corrosive problem at hand, stainless steel remains practically impervious to attack.

The every-day significance of high corrosion resistance in a utilitarian metal is tremendous. Huge sums are spent each year to replace rusted equipment, to maintain all manner of structures with painting and repairs, and to fight the contamination that corrosion entails. Back in 1922, the annual cost of corrosion to the world was estimated by Sir Robert Hadfield at $3,500,000,000.

In the petroleum industry, equipment that used to be replaced in a matter of weeks now lasts for years because it is made of stainless steel. Vast chemical processing plants use stainless piping, tanks, mixers, heat exchangers, pumps and fittings—protecting the product from contamination. This equipment stays on the job without undue maintenance or repair cost, even under corrosive conditions that would be prohibitively expensive to handle with less resistant materials.

Corrosion resistance means cleanliness and safety in food handling. From the big meat packing, dairy, gen-

eral food processing, canning, bottling or packaging establishments to the housewife's kitchen sauce-pan, stainless steel is a guardian to health. Repeated cleaning and sterilizing, hard, continuous use, and the attack of food acids pose a tough set of performance standards that stainless meets admirably.

Textile and paper mills operate more economically and make better products because stainless equipment helps them to avoid contamination as well as to cut down repair or maintenance expenses.

In architectural uses, stainless has barely touched its potential usefulness. As the advantages and economies of stainless construction over the use of stone, brick and other traditional materials are more widely appreciated, stainless steel will gain a very prominent place in the architectural field. Today, store fronts, signs, public rooms, entrances, doors and window frames are popular stainless applications. Eating places use a great deal of stainless steel because food-handling equipment gave restaurant people a first-hand introduction to its benefits.

Curtain walls, made of panels with insulating material sandwiched behind stainless sheets, are now used on large buildings. A three-inch panel of this sort gives the same insulation as 12 inches of masonry, with a tremendous weight reduction. It offers a first-cost saving in installation time plus a bonus of yearly revenue from extra, usable space inside the building.

In small homes, too, stainless sinks and kitchen fixtures are being installed. Rain gutters, flashing and downspouts in dull, satin-finished stainless steel provide beauty and permanence at a cost comparable to that of other long-lived materials.

High-temperature applications in industry are numerous, but they are usually so specialized that they rouse little public interest. For example, carburizing pots made of heat-resistant stainless steel endure repeated cycles of 1800° F. to room temperature—treatment that would soon destroy most metals.

Jet airplanes, on the other hand, excite one's imagination as they push on to higher and higher speeds. Many important parts of these aircraft depend on the high-temperature strength of stainless steels. The skin on wings and fuselage reaches intensely high temperatures, and it takes a merciless buffeting in the speed range of the sonic barrier. Light alloy sheets cannot stand this combination, but stainless steel skin construction makes it possible for an airplane to penetrate the barrier and to fly at amazing supersonic speeds.

Jet engines for high-speed planes have been made possible by metallurgical and scientific advances on many fronts. Important among them have been the development and continuing perfection of many high-temperature engine parts. Some of these parts have been successful and practical solely because of the high-temperature corrosion resistance of the stainless steels that went into them.

The continuing research of the steel industry, and the constant testing of all grades of stainless under the severest conditions result in steady improvements in their manufacture and application.

Stainless steel is truly a modern metal: a product of the 20th century—great in its usefulness to man—but with almost unlimited areas yet to be explored. ●

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Summer Conference

of the New England Association of Chemistry Teachers

Some 500 members of the New England Association of Chemistry Teachers will meet with 100 or more non-member guests from August 21 to 26, at the University of Connecticut, Storrs, Conn. This will be the Twelfth Summer Conference of this well known organization whose membership is about equally divided between college and secondary school teachers. The NEACT is affiliated with the American Association for the Advancement of Science.

Sixteen talks and demonstrations will be presented by distinguished speakers from many parts of the country. Among the topics already listed are:

Electrochemistry in the Freshman Course
Chemistry Applied to Archaeology
Chemical Problems of the Frozen Foods Industry
Modern Chemistry in Amino Acid Synthesis
Panorama of Steel
Plant Hormones in Practice
University Service to Industry
Crystallization and Crystal Growth
Micro-chemistry
Isotopes
Recent Advances in Fluorine Chemistry
Medical Aspects of the Atomic Bomb

The N.E.A.C.T. Summer Conferences provide an opportunity for teachers to acquire the latest scientific information in a number of fields, as well as modern techniques of teaching. In general the Conferences are very practical. There is ample opportunity for private conference with the speakers and with the other experienced teachers and professional men and women in attendance. Learning is made easy by the informality of the meetings and the pleasant vacation atmosphere. The value of these Conferences has become so well known that teachers are attracted from far outside New England. Many who attend bring their families. All who care to come are invited. Recreation facilities are numerous and convenient.

Little expense is involved in attending. Registration and college hostelry fees are surprisingly small.

Anyone, member or non-member, who desires more complete information should write the Secretary of the Summer Conference, Mr. Carl P. Swinnerton, Pomfret School, Pomfret, Conn. The complete program and descriptive information can be obtained from him, without obligation, after June 1. ●

NEW BOOKS

Science is a Sacred Cow

• *By* ANTHONY STANDEN. New York: E. P. Dutton & Co., Inc. 1950. Pp. 221. $2.75.

This book of sharp crititism will not add to the complacency of scientists of any kind or rank. Perhaps it was time for someone to say some of the deflating things Mr. Standen says—with tongue in cheek at times perhaps—but always good humoredly. He charges at the sciences and the scientists, at the scientific attitude and the scientific method, at the awe in which scientists are held by laymen (who get their information about science from scientists). He criticizes the cocksureness of scientists and points out their lack of precision in defining terms.

To Mr. Standen "other so-called sciences are scientific in so far as they approach the dignity of physics, and it would be only a slight exaggeration to say that physics *is* science, physics and nothing else . . ." "If you take a course in biology, or read any of the textbooks, you will find extremely little that can be scientific in any scientific sense." Concerning chemists . . . "much of what they do is an art, related to cooking, instead of a pure science." And again: "There is one science, and only one, that is actually true. That is mathematics. The others from physics downwards, do not lead to known truth, but only to probable opinion . . ." "The first purpose of science is to learn about God, and admire Him, through His handiwork. If any usefulness comes in—as it does in large quantities—why, so much the better."

Scientists will find many points of disagreement with Mr. Standen, but they can't afford to ignore his challenging statements.

H. C. M.

Measuring Our Universe---*From the Inner Atom to Outer Space*

• *By* OLIVER JUSTIN LEE. New York: Ronald Press Co. 1950. Pp. x + 170. $3.00.

This is a delightful book by an expert in the field of precision measurements. The emphasis is on outer space rather than inner atoms, which is quite natural on the part of a man who is the emeritus director of Northwestern University's Dearborn Observatory.

After discussing the origin and development of our units of measurement and the construction of some precision instruments, the author focuses the reader's attention on methods of determining distances to heavenly bodies from the moon to the dimmest and most remote galaxy. Those readers who have never thought of it will be completely fascinated by the author's description of the determination of the diameter of the earth, or that of a star. The initiated should still find this book as breathtaking as the best adventure stories ever written. Few accomplishments of man challenge the imagination more than inferring the structure of the universe by measuring the distance between a couple of spots on a photographic plate, or comparing the position of lines on pictures of spectra from stars. No one, in this reviewer's opinion, has told this story in a more engaging fashion than Professor Lee.

The only criticism, if this be any, is that while the book was apparently written for laymen, some rudimentary knowledge of trigonometry will be very helpful to the reader.

M. Ostrofsky
Department of Mathematics
Duquesne University

Biology in Our Lives

• *By* GEORGE W. HUNTER, Ph.D., and F. R. HUNTER, Ph.D. New York: American Book Co. 1949. Pp. 534. $3.40.

The order of presentation of material in this high school textbook makes it unnecessary for the teacher to skip around when he uses living specimens from the field. The illustrations are superior. References to popular subjects are frequent enough to be appealing to the student. The general format is good, the two-column page permitting illustrations to be placed near the point in the text where they are discussed. The three types of questions located at the end of the chapters are designed to encourage the student to think independently.

The style of writing and the organization of information about a given subject are such that skillful teaching will be necessary in order to prevent the subject of biology from becoming a superficial accumulation of interesting facts for the students who use this book.

Helena A. Miller
Department of Biological Sciences
Duquesne University

Principles of a New Energy Mechanics

• *By* JACOB MANDELKER. New York: The Philosophical Library. 1949. Pp. VIII + 73. $3.75.

The author attempts to find transformation equations between inertial frames while preserving the isotropy of light propagation and absolute time. He claims to achieve this by permitting the velocity of light to vary from one frame of reference to another. His transformation is based on the relation:

$$x^2 - c^2t^2 = x_1^2 - c_1^2t^2$$

Apparently the author is unaware of the fact that this is not a transformation linking two frames with constant relative velocity. This error is introduced at the very outset of his derivation (p. 9).

The author introduces such unusual concepts as kinetic and potential momentum, also kinetic and potential force. Finally, he applies his theory to wave mechanics. His arguments are frequently rather obscure.

M. Ostrofsky

Fieldbook of Natural History

• *By* E. LAURENCE PALMER. New York: McGraw-Hill Book Co. 1949. Pp. 664. $5.00.

This book is encyclopedic in nature, embracing in epitomized form and under separate categories much useful information on stars, rocks and minerals, plants, animals, fishes, reptiles, and birds. It is intended primarily as a textbook for natural history in colleges and universities, but it will also serve as an excellent reference work for high schools. It contains more than 2000 items and numerous illustrations. Each item is accompanied by a short descriptive identification followed by data on range and location, life history, ecology, and economic importance.

H. J. Kline, C.S.Sp.
Department of Biological Sciences
Duquesne University

Webs in the Wind

• *By* WINIFRED DUNCAN. New York: Ronald Press Co. 1949. Pp. xv + 387. $4.50.

To all nature lovers, scientists, teachers, students, and laymen, this should be a fascinating book. It is a first person singular account of a patient study of the habits of web weaving spiders that covers some two years of time and some 10,000 miles of travel. Upon finishing it, one has the impression that there must be little about the private lives of the creatures she studied that the author has not discovered. She describes vividly how she conducted her researches concerning web architecture, life cycles, danger signals, food, mating, reactions to light, sound, and scent, and many other aspects of spider life. She permits the reader to reason with her from observed facts to final conclusions. The 101 drawings and 74 plates, beautifully drawn by the author, add much to the clarity of the descriptions and to the beauty of the book. Mechanically, "Webs in the Wind," a volume of the Humanizing Science Series, is an example of good book making.

H. C. M.

Biology

• *By* FRANK M. WHEAT and ELIZABETH T. FITZPATRICK. New York: American Book Co. 1949. Pp. xxxvi + 571. $3.50.

This book, designed for use in second year high school classes, is worthy of careful examination. The various artifices the authors have employed to attract and hold the interest of young students reveal clearly that they are experienced teachers. The book's nine units are subdivided into thirty-eight problems. Each problem is followed by a summary, and a list of thought-provoking questions which help to stress the more important concepts treated. Illustrations and diagrams are plentiful and good. Technical terminology is avoided when possible, and the scientific terms that are employed are clearly defined.

H. J. Kline, C.S.Sp.

Alcohol and Human Affairs

• *By* WILLARD B. SPALDING and JOHN R. MONTAGUE, M.D. Yonkers-on-Hudson, New York: World Book Co. 1949. Pp. vii + 248. $1.64.

This book, written for high school students, can be read with profit by many adults, even by those who hold strong points of view on either side of the question to use or not to use. It is an engagingly frank discussion of the whole alcohol problem marked by sound good sense and honesty and an unemotional approach. The authors show that there can be both good and bad in the manufacture, sale and use of alcoholic beverages. They point out what intelligent people have tried to do and have done about the liquor problem. They present an array of facts pertaining to this complicated question that will help the individual to reach a personal decision. Some space is devoted to the attitude of various churches as to the use of alcoholic beverages by their members. An appendix considers the tobacco, narcotic and drug problems.

The fact that the authors of this book are the dean of a school of education and a medical specialist guarantees the soundness of the book from the educational, scientific, and medical points of view. The book should do much good.

H. C. M.

★ ★ ★ ★ ★

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Science, September 24, 1948

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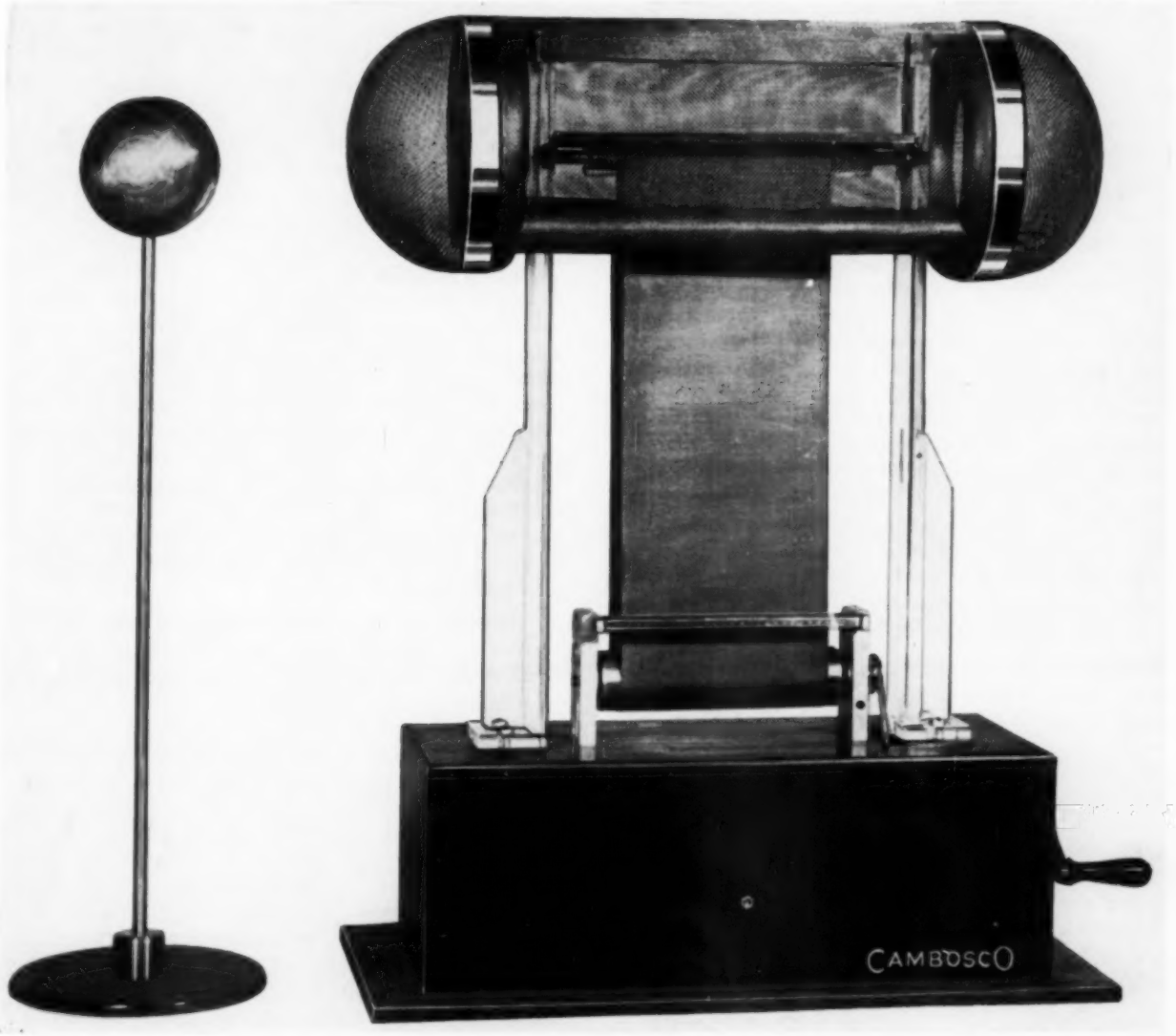

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(Continued from Page 62)

when completed, a capacity of about 7,000 barrels of liquid products daily.

The Bureau of Mines is also constructing a demonstration synthesis plant feeding coal which will produce about 85 barrels per day of liquid products. There is at present no commercial-size synthesis plant based on coal known to be under construction or contemplated in this country.

Although from the standpoint of process economies natural gas appears to be the preferred raw material for hydrocarbon synthesis, its availability is limited. The known or proved natural gas reserves in the United States are currently estimated to be about 180 trillion cubic feet. If this volume were all converted to oil it would yield about 16 billion barrels, equivalent to around 70 per cent of the petroleum proved reserves. Obviously all of the gas would not be available for synthesis, much of it being required for heating purposes and chemical uses. Present production of natural gas amounts to 6 trillion cubic feet a year. On the basis of past experience, it has been estimated that production might be increased to make available about 4 trillion cubic feet a day for hydrocarbon synthesis. In that case, it would be possible to produce only about 400,000 barrels of oil per day, approximately a fifth of the volume of gasoline consumed daily in this country.

Opinions differ as to coal reserves in the United States. According to an old estimate of the U. S. Geological Survey, reserves amount to 3 trillion tons, enough to supply the country's needs for both coal as such, and for making oil, for a thousand years. Some regard these figures as too high. But, in any case, coal reserves greatly exceed the reserves of natural gas now known or expected to be discovered. The amount of oil that can be made from a given quantity of coal depends upon the type of coal used: whether it is anthracite, bituminous, sub-bituminous, or lignite. Assuming that one-half ton of coal, on the average, would be required to furnish one barrel of oil, to supply gasoline at the rate it is presently being consumed in this country would necessitate increasing coal production by 450 million tons a year, or nearly doubling the present production rate.

Coal mining cost is important in the coal process. In this connection, interesting experiments have been carried out in Alabama on a process said to be practiced in Russia, known as underground gasification of coal. In this process, a passageway is cut through a coal bed, air blown through it, and the coal fired in the mine. In this way with proper controls a mixture of carbon monoxide and hydrogen suitable for synthesis should be obtainable. Results to date, however, have not fully established the practicability of the process.

It is evident that there is at hand considerable experience on the production of liquid fuels from non-petroleum sources. Shale oil, natural gas, and coal can be counted upon to supply large volumes. The desirability of going into the immediate construction of commercial plants on a large scale is not so clear. Plants built today may be obsolete by the time they are needed.

From published figures it appears that the plant investment required for producing a synthetic gasoline in volumes equivalent to the gasoline consumption in this country would be around $20 billion and would call for 20 million tons of steel.

There are two phases to the question of ability to meet the country's need for liquid fuel. One concerns the need for normal peacetime consumption. This need can be met from petroleum with the gradual installation of synthetic oil facilities as they become economically justified. The other phase relates to furnishing adequate supplies of liquid fuel in time of national emergency. In the last war all military needs were met from existing petroleum manufacturing facilities through rationing of gasoline and fuel oils and the continuing expansion of the facilities at about the usual peacetime rate. In 1941, the year the United States entered the war, domestic oil production was 1.5 billion barrels, while in 1948 it was 2.2 billion barrels, over 45 per cent higher. The normal annual increase in petroleum production plus peacetime stockpiling present an attractive insurance against sudden military requirements in a national emergency.

Research on any process is necessarily far in advance of practical application. The petroleum industry has always been faced with steadily expanding needs for oil products. Even before the introduction of hydrogenation over 20 years ago, considerable advances were made in research on shale oil production. But adequate petroleum supplies discouraged commercialization of shale oil at that time. Since 1938—with the exception of the war years, when research had to be directed toward more urgent problems—research has been carried out on the Fischer-Tropsch process. In 1947, the petroleum industry expended over $10,000,000 on such research. Out of the research have come many improvements in the process, some of which have been mentioned. These will be reflected in economies in construction and better product quality when the installation and operation of commercial units are undertaken.

Eventually oil shale, coal, or natural gas may join petroleum as sources of liquid fuels. For the present, continued extension of petroleum reserves, together with improved producing methods resulting in increasingly high recovery of oil from the reserves, promise adequate petroleum supplies for a long time to come. But from the technical information already available, commercial plants for manufacturing substitute liquid fuels could be designed now. And the research in progress will make available material improvements in the processes when the need for substitute liquid fuels becomes a reality. ●

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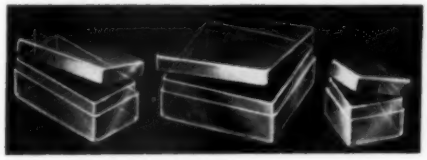

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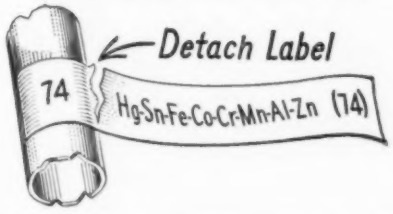

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Sulfur and Life

(Continued from Page 49)

tained regarding the role of sulfur in soil fertility, plant nutrition and the well-being of humans and animals. A great advance was made in our knowledge regarding the place of sulfur in agriculture when Hart and Peterson applied new research techniques to the problem and showed that our former concept regarding the sulfur content of plants was all wrong. Today again, new techniques are being applied to the problem. These involve the use of radioactive sulfur and tracer materials. New and important information is being uncovered with regard to the fate of sulfur in the soil as related to changes induced by microorganisms and chemical reactions. It is believed that these new techniques will greatly advance our knowledge regarding the function of sulfur in soil fertility, plant and human nutrition, and human well-being. Perhaps these new techniques will give us a better appreciation of the place and function of sulfur in the cycle of life. ●

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Nutrition Education

(Continued from Page 58)

mittee may be the answer. It should include members of the student body as well as teachers from all departments of the curriculum.

Continuing to emphasize nutrition education throughout the high school years in all branches of the curriculum, and providing opportunity and encouragement for students to practice improved dietary habits, will give rise to better diet practices, resulting in better health not only for the students themselves, but for their future families.

Four "C's" are necessary for success! It is only by *concerted, cooperative, coordinated* and *continued* planning on the part of the administration and faculty that such an aim can be achieved. The four "C's" for nutrition education cannot be attained in a single term, any more than they can be for other educational aims. The first step is to be aware of the need! ●

On the Path of an Eclipse

(Continued from Page 52)

Within twenty-four hours we had garnered in fourteen time signal stations from all over the world, most of them strong enough to record. While listening one morning I heard the powerful government station KRHO in Honolulu rebroadcasting WWV. The announcer said that it was a test for the eclipse expeditions. We were not the only ones having difficulties with reception from the other side of the world. Two days later a cable informed us that KRHO would be on a regular schedule of broadcasts for our benefit. Our important time signal problem was solved.

The chronometers which were needed to keep the correct time which we recorded from KRHO were acting very strangely. No wonder! The temperatures at night on the mountain sank to the fifties and in the daytime they soared over a hundred. No precision time piece could stand such a range in temperature. We buried the chronometers in the ground (along with our supply of fresh butter) and covered them over with several boards. The chronometers settled down to steady rates immediately.

As May ninth drew near the surveyors completed their task. Each team delivered a carbon copy of their theodolite readings and computations to me to bring back to Washington. The final result showed that we were about six hundred yards off from the central line of the eclipse. The map we had used was that much in error. We debated moving to a new site, but decided against it because the concrete piers had already been laid and we would have had to send to Hangchow for more concrete and sand. The six hundred yards would not affect our observations seriously, and the eclipse day was getting too close for radical changes in our site.

We were more concerned with last minute adjustments of the focus. During the past week we saw very little of the sun. On one day it rained so hard that the dampness began to creep into everything. In between showers we set up our camera and coelostat and rehearsed every move we were to make while observing the eclipse. There would be no excuse for an observer failing to throw the right switch at the right moment. We were a perfect team by May eighth when the sun appeared long enough for a final rehearsal and focus test. We were confident that the rainy weather was passing and that the next day would be clear.

That night I watched the stars come out. Some twinkling here and there indicated the presence of thin clouds. I felt sure that these would dissolve before morning. At midnight I retired, but woke up at three o'clock. A gentle rain was pattering on our tent. Everyone seemed to wake up as suddenly as I had. What was there to do? I said Mass and prayed fervently for a clear morning. God decided otherwise. A completely overcast sky greeted us at daybreak.

Near eclipse time Colonel Crane from Shanghai, Colonel Wynne from Hangchow, and a party from the American Embassy in Nanking appeared on the last stretch of the trail to Wun Long Climb. The pilots of the planes who had flown them in to Hangchow told me that the cloud cover consisted of two dense layers at 5000 and at 8000 feet. All hope of observing any part of the eclipse vanished when we heard that.

Our equipment stood in readiness all morning, but at noon a few drops of rain began to sprinkle down. The rain had returned. The afternoon became progressively more disagreeable. The Chinese farmers toiled down the slippery trail with boxes of equipment slung on bamboo poles as fast as we packed them. By nightfall the tents were down and we bade goodbye to the scene of our latest and bitterest disappointment.

The rain continued all night and all the following day. Despite it, we hauled the truck full of equipment to the airport at Hanchow where it could be loaded on a plane for its return flight to Washington. Colonel Wynne entertained us with a movie and consoled us with a fine dinner, the best we had had in more than a month of K-rations and bamboo shoots. Driving back to our camp that night, we plowed through mud and deep puddles. The water level at our camp site had risen to within a few inches of the top soil. We had to get out very fast. By noon our tents were all rolled and packed into the truck with the kitchen stove and everything else we had brought with us.

It was time to say our farewells to the Chinese soldiers who had guarded our camp during our stay and to the villagers who had told us that we were the first

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white men to visit them. The thinly bearded patriarch of the village brought my interpreter over and told me that after we left there would be no joy in his village. His reason for the compliment was the affection we had showed to the children who had all but lived with us, and the generosity with which we had paid for every service the farmers had given us.

Back in Washington, I reported with the only results I had to show for the expedition—the data from the Chinese and American Army surveyors. It was a great satisfaction to learn that the data filled in a gap in the records of the Army Map Service for that part of China. That alone made the expedition worth while. ●

Earthworms Rejuvenate Soil

(Continued from Page 47)

and if earthworms were introduced to break this waste down into rich humus, bacteria and other forms of soil life would again return. In a few years our soil would be healthy and able to support healthy plants, which in turn would support healthy men and animals.

We believe that this procedure along with other conservationist practices, such as reforestation, river and stream clean-up programs, contour plowing, strip planting, and the elimination of one-crop agriculture, will go a long way toward protecting our natural heritage, and enable us to give a good accounting to our children for the years of our husbandry. ●

Radioactive Isotopes

(Continued from Page 54)

results have been discouraging. More recently, due to the availability of radioactive cobalt (cobalt 60) from Oak Ridge, a new method of administering treatment very similar to radium treatment has been possible. Radioactive cobalt can be supplied in the form of wire, or in special shapes which make it easy to provide radium-like treatment to cancerous areas. Radium of course, cannot be supplied in various shapes and therefore the availability of radiocobalt makes it possible to treat more effectively certain areas that could not be handled as well with radium. A big advantage of radiocobalt is its low cost. Its present price means that radiocobalt can be purchased by the X-ray man in the small hospital that ordinarily could not afford a radium supply.

ANNOUNCER: This sounds as if cobalt extends the availability of radium-like treatments to community hospitals and to smaller hospitals in rural areas. Does this mean that the average physician can use radiocobalt in his office?

COOK: No. The handling of radiocobalt is every bit as dangerous as the handling of radium, and it is most important that the doctor using these substances be specially trained in the technique and precautions necessary for the safe and effective

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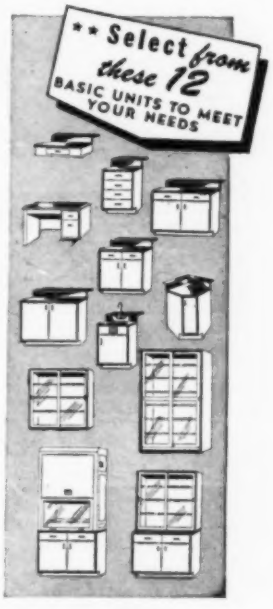

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treatment of patients. Although this substance is fairly readily available, it is much too dangerous to be used by doctors untrained in the special techniques necessary for handling radium and radium-like substances. These isotopes are all extremely dangerous. Radio cobalt is one of the worst.

ANNOUNCER: We've talked about radioactive isotopes. What about these new instruments that have been described in the newspapers recently, known as "betatrons." Would you care to comment on their usefulness?

FRANKE: The betatron, such as the one at the University of Illinois that has been mentioned in the papers so much recently, is designed primarily to treat cancer with tremendously high energies. The X-ray machines used in cancer treatment may generate as much as a million volts of energy, whereas the betatron is designed to have an output 25 or 30 times as much. It is hoped that this will mean more effective treatment of cancer, particularly cancer in deeper structures not ordinarily accessible to X-radiation. However, this machine has not been extensively tried and the investigators operating it are hopeful, but not over-enthusiastic, about its long-term results.

In considering the results of treatment in any type of cancer one must recognize that it is not usually an abrupt disease with a short course, but a long drawn out process. Therefore it is necessary in considering the results of treatment not to draw any conclusions about favorable results in a month or three months or six months, but to follow the patients carefully for some two to five years before feeling that the results of treatment with a new technique are more effective than older procedures. Every few weeks some new measure is hailed as being valuable in the treatment of cancer, yet with the passage of a few months each of these new treatments has gradually decreased in value.

As you well know, at this time, we do not have any absolutely certain method for the treatment of cancer. There is every hope that with the intensive research now going on, such a treatment will become available in the near future. However, it is almost certain that when a successful treatment is devised, it will require careful long-term evaluation before its worth can be established. We do not feel, at this time, that any radioactive isotope will ultimately be the treatment of choice in cancer, but we feel certain that important information gained by medical investigators from radioactive tracer experiments will enable them to better understand cancer and thereby to devise effective therapy. ●

What is Science?

(Continued from Page 44)

and other virtues. These contrast with human tendencies to low ideals, uncouth tastes, indifference to ugliness, a contentious society, belief in superstitions, and other vices.

Typical of the humanistic studies are art, music, poetry, literature in any language if noble in form and purpose, history that deals with broad human efforts rather than petty rivalries of persons, though they be kings and generals.

Any knowledge that contributes to a more noble race of men may be embraced in a humanity. The intellectual aspects of civilization, as distinguished from the purely technical aspects, are the humanities. If a study broadens the horizon of a student's viewpoints, challenges his mind instead of merely his memory, makes him a critical thinker instead of merely a critic, it is a humanity.

Does science offer these values? What studies are more broadening, more challenging, more demanding of accurate thought, than science? What area of knowledge has played any greater part in building the present civilization of the enlightened nations of the world?

But therein lies a seeming contradiction—science can destroy civilization! This fear has been voiced by too many earnest scientists themselves to be ignored. When these warnings are analyzed, however, it is clear that it is not science as a humanity, but *inhuman* science, that has the power of evil to the human race.

This is not a play on words. Nature is cruel if her laws are violated. The unwary climber falls, the careless hand is burned, the reckless swimmer drowns. When men choose to use inventions to kill other men, the evil is in their hearts, not in their tools!

Today we see a world full of conflicts and suspicion. Economics, through the commerce of the centuries, has not brought peoples together in mutual trust. Politics through organized governments has developed nationalism rather than internationalism. The free exchange of literature that the printing press made possible has brought no common language or philosophy. The radio's great possibilities of world-wide understanding are far from being realized. And religion, with all the missionary effort that has been expended, must still find comfort in the admonition, "And let us not be weary in well doing, for in due season we shall reap, if we faint not." (Galatians 6:9.)

Possibly science may at last bring the world together, with the cooperation of other noble forces. The laws of music are the same in any church where the organ swells its tones. Even the Russian children must learn the same laws of the lever as are taught in the hated Western nations. Whether acquired characters can (Russian theory) or can not (rest of the world's theory) be passed on by heredity does not permit the repeal of Mendel's Laws by any Council or Dictator. No true principle of science ever depends upon a political boundary for its application.

It is also true that scientists, acting normally, ignore the boundaries of nations and the latitude of cities. The greatest worldwide meetings held in untroubled times have been those of the scientists. More than other groups, scientists are eager to share ideas, learn how others experiment, carry on cooperative projects even in stations separated by half the world. Indeed they accept in sincerity the wisdom of *Voltaire* (1694-1778, French philosopher): "He who seeks truth should be of no country."

What, then, is science? It is truth learned by scientific means. It is the art of using science helpfully. It is the craft that employs scientific skill. It is that recreation in which Nature is a pleasant companion, ready to have fun with you. It is a religion for which some men will die, and others suffer. It is a language that expresses a way of thinking suited to each age above infancy. It is one of the humanities, lifting the culture of the human race. It is a hope—a major hope—possibly the chief hope—for the preservation of human civilization.

The devout thinker links his hope in science with his trust in God. To this thinker the laws of Nature are the laws of God. He agrees with *Blaise Paschal* (1623-1662, French scientist-philosopher) that "Nature has perfections, in order to show that she is the image of God; and defects, to show that she is only an image."

Surely God created the world of natural law and order so that man's dominion over it might be a task within man's powers. Suppose man really had the responsibility for the rising and setting of the sun, the moon, and the stars! Suppose man had to carry water from the oceans to the mountains, so that rivers could flow! Suppose man had to compound all soils for farms, instead of merely to enrich them after his own wasteful tillage! Suppose a man had to get all of his neighbors to agree on the weather for tomorrow! Suppose man had to lay in the coal and the iron, rather than merely to dig them out! Suppose man had to pour the right mixture of hydrocarbons down into the deep sandstones, instead of merely to pump the crude oil up. Suppose man had to make an ear of corn instead of merely keeping the worms away! Suppose man had to make a tree for wood, stone for steps, and mingle the right stuff in clay for bricks! Suppose man had to take his beakers and flasks into the laboratory, and mix the right chemicals to make an egg! Suppose a man had to make a baby!

Although we complain much and often, we know in our hearts that the Creator has made the world ready for our dominion. Science is a way of learning His laws, and applying them to the needs of men. The scientist is a person of noble calling, even though of humble duty. I am thankful that I have been allowed to learn at least a little science. I am proud to be a science teacher!

After writing the final word of this speech, I stood before a wire fence. On one post I hung my hat; on the next my coat. The third post bore my necktie, and

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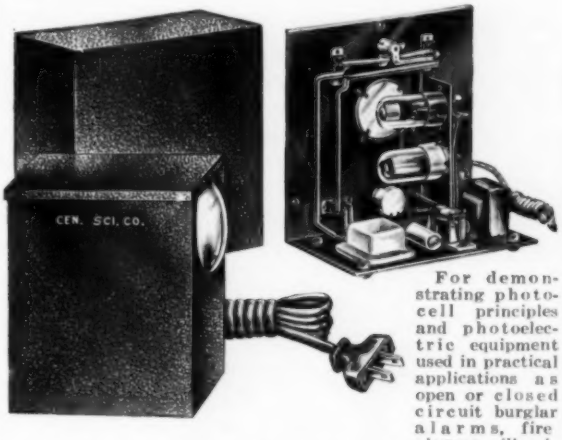

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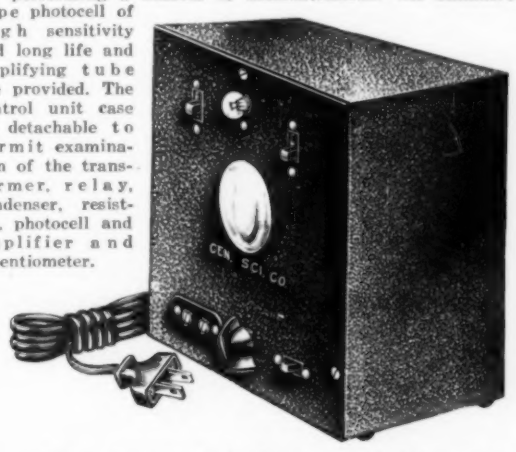

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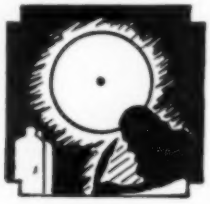
the fourth my sweater. With this as the front row of an imaginary audience, I proceeded with this address. I said "for example" much oftener than on these pages. I used all gestures that came to mind. I paused for laughter at the proper places. After certain paragraphs it was necessary to stifle some assumed applause. At the end there seemed to be vigorous handclapping, but this proved to be a truck coming over the hill.

The point of all this experimenting was to measure timing. The speech took exactly twenty minutes. If I recall your invitation rightly, this was the time suggested by your sponsor.

I have no present engagement to speak *our* piece to any audience. I will accept the first invitation, but frankly I hope *you* have the first opportunity. When you have given your best effort, I would be pleased to learn the nature of your audience, and how they liked you as a speaker. ●



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Teaching of Science Courses

(Continued from Page 64)

just a few of the problems that confront the pioneers. Most of the men engaged in teaching these courses feel that they have met with some degrees of success. They are anxious to continue the work, which they trust will better acquaint the laymen with this modern world where he must live, taking his part as a responsible citizen in the "social changes which flow from the relentless advance of science and techniques."[6] ●

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Work With Daphnia

(Continued from Page 42)

artificial pond water and in the conditioned water Daphnia survived for about a week. Apparently there was too little food, or perhaps not enough of the proper kinds of food.

I decided to discard the fresh water, and also the artificial pond water which required the use of chemicals, weighing, etc., and to experiment further only with conditioned water. I wanted to find a method for propagating Daphnia continuously, especially a method entailing as little time, effort, and expense as possible. To obtain water sufficiently conditioned for my purpose, I filled an aquarium with tap water and balanced it with goldfish, snails and plants. For plants, I used elodea, and duckweed or Lemna minor, a small plant which can be seen floating on the surface of ponds. To insure the presence of the smallest algae and diatoms found in ponds, I added a small amount of pond water. I was careful not to overstock by adding too many goldfish. For snails I used Physa and Lymnea. I allowed the water to become well conditioned by not disturbing it for two weeks before using. Eventually I learned that it is well to maintain a second aquarium in order to ensure a steady supply of properly conditioned water. To exclude dust and dirt the aquaria should be covered with glass.

When I had on hand a good supply of conditioned water I began experimenting to find 1) how environmental factors such as light, temperature, food and water affect Daphnia; and 2) a suitable laboratory method for culturing Daphnia continuously.

First, I placed four glass pint jars next to a window with the window slightly open, to study the effect of exposure to cold and strong light. I covered one jar, leaving three uncovered. The specimens in all four jars were fed the same kinds of foods, but varying in amount. The third jar received about twice the amount of food given the first two jars, while the fourth jar received three times as much.

Next, I placed four other jars as close to the radiator as possible, near a window, repeating the foregoing procedure. To determine the effect of a medium amount of light and average room temperature four jars were placed on a table in the center of the room. To determine the effect of darkness, I placed four containers in a room without windows, keeping the door closed.

All the jars received the same kinds of food. Several small snails acted as scavengers. Two of the four jars in each series received one sprig of elodea, a piece of fresh lettuce leaf about one-half inch square, about one-fourth teaspoonful of water containing duckweed plants, and finally, a sprinkling of fine, dry sheep manure and a pinch of hard-boiled yolk of egg, the latter two substances being added not more than once a week.

Upon finding all the cultures alive after two months had passed, I narrowed my experimenting to six jars, placing two on a table in the center of the room, two near a window, and two far from the light. One jar of each pair was covered. In the original series, the jars which received a triple amount of food showed the greatest degree of cloudiness, accompanied by an unpleasant odor and a definite waning of the cultures. In this new six-jar series one of each pair received twice as much food as the other.

At the close of the school year all my Daphnia were still alive. I took one culture home and kept it going until the opening of school in the fall. All the cultures did so well in conditioned aquarium water, that I consider such water almost a "must."

Sub-culturing is a very important factor in growing Daphnia. Should it appear that one of the cultures is dying out, you should sub-culture at once. Probably it will not be necessary to treat all jars at the same time. I have kept cultures in good condition for over a month before finding it necessary to sub-culture. The procedure is simple.

Take a clean glass jar, pour into it not more than one-third of the culture requiring treatment, preferably the upper third so as to exclude the muggy water at the bottom. Do not disturb the old culture any more than is necessary. Now fill the new jar with aquarium water and add the elodea taken from the older culture. You may prefer an alternate method. Fill a clean jar with aquarium water and inoculate with Daphnia by using a fine fish net. Finally, add the foods in the prescribed amounts.

In time you will find that you can keep Daphnia cultures going satisfactorily even though you vary considerably the amounts and kinds of foods. It can be done with as few as three jars on your desk, where some sunlight is available. The important thing to remember is to sub-culture in time.

Of What Value?

For microscopic study I know of no living organism of greater interest than Daphnia to the average high school student. What can be more absorbing to young and active minds than to see the pulsating heart of a living creature without resorting to dissection, the various other functioning organs, the development of the young within the body of the mother? Is it not a mistake to have students study preserved material when living animals can be so easily obtained? What organism is better adapted for discovering science talent, and for introducing students to research and research methods? What student will not be thrilled at the opportunity to culture Daphnia and to watch their reactions to various kinds of food, to environmental changes, and to other factors?

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The Velocity of "Second Sound"

Scientists at the National Bureau of Standards have succeeded in settling an international controversy of basic theoretical importance in the perplexing field of low-temperature research. To achieve this, J. R. Pellam and R. B. Scott of the Bureau have measured for the first time the velocity of "second sound"—that unique process by which heat is transferred through helium II (the fourth state of matter)—at temperatures well within one degree of absolute zero. Their results, in addition to settling the international controversy, have cleared the way for further research at super-low temperatures. In particular, the work opens up the possibilities of getting to extremely low temperatures, close to absolute zero, by new methods.

Helium changes from a gas to a liquid at only 4.2 degrees Centigrade above absolute zero. (The lowest temperature that can ever exist is absolute zero: minus 273.16 degrees Centigrade, or zero degrees Absolute, which is 273.16 degrees below the temperature of melting ice.) Between the temperatures of 4.2 and 2.19 degrees Absolute, liquid helium behaves as a normal fluid. In this state it is known as helium I. At 2.19 degrees and below, however, helium I changes into the liquid form known as helium II. The characteristics of helium II are so unlike those of helium I or of any other fluid that it is often referred to as a fourth state of matter, or as the quantum fluid: its properties seem almost supernatural.

One of these unusual properties is its strange ability to transmit heat. In all other forms of matter, heat diffuses from one point to another at a comparatively slow rate through the collision of one molecule with another. In liquids other than helium II this process is extremely slow. In helium II, on the other hand, heat is transferred thousands of times faster than in any other substance (including metals) by means of a peculiar kind of wave motion. Because this motion is similar to that of sound waves, the process of heat transfer in helium II is known as "second sound." Unlike ordinary sound, second sound is detected by a temperature-sensitive device rather than a microphone.

The remarkable properties of helium II have led to two mathematical theories, each of which predicted second sound before it was ever observed. These two theories agreed with each other at temperatures ranging from 1.3 degrees Absolute to 2.19 degrees Absolute. The critical difference in these theories was in their prediction of events below 1.3 degrees: one theory postulated that there would be a sudden rise in the velocity of second sound; the other that there would be a decrease in the velocity.

The experiments of the National Bureau of Standards have indicated conclusively that there is a rise in the velocity, thus nipping the controversy which has raged between exponents of the two rival theories, and pointing the way to further research. Not only was an unmistakable increase in velocity observed below 1 degree Absolute, but the value nearly doubled, rising smoothly from a minimum of 60.4 feet per second at 1.1 degrees Absolute, to 111 feet per second at a temperature between 0.5 and 0.7 degree Absolute.

These results clarify the direction of future experiment and theory in this field. They also indicate the possibility of producing extremely low temperatures by new methods: Helium II consists of two kinds of fluids. One portion is a normal fluid; the other is a superfluid which accounts for the remarkable properties of helium II. When helium II passes through an opening less than 1/100,000 of an inch in diameter, atoms of the normal fluid are left behind while atoms of the superfluid pass through alone. Because the superfluid atoms, according to the theory established as valid by the Bureau, do not take any heat energy with them through the opening, the temperature on one side of the opening must be considerably reduced. It should thus be possible to go to lower and lower temperatures by repeatedly passing helium II through small openings. Perhaps in this way temperatures very close to absolute zero can be reached. ●

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